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APPLIED MECHANICS REVIEWS

VOL. 13, NO. 4 APRIL 1960

THE THEORY OF FLAME PROPAGATION

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The theory of flame propagation is based on the equations of aerodynamics generalized to include the effects of chemical kinetics. These equations are well known (1); yet a great deal of research remains to apply the theory to practical flame systems. The most extensive research has been carried out on one-dimensional steady-state flames supported by a unimolecular reaction. The characteristics of such flames have been determined both by numerical integration (2,3) and by various approximation schemes (4–11). Surprisingly, it has been ascertained that there is a maximum amount of heat which the flame holder can extract without extinguishing the flame. For smaller amounts of heat transfer from the flame to the flame holder there is both a stable burning mode with a relatively large flame speed and an unstable mode with a smaller flame speed (2,12,13). As the ambient pressure is decreased, the burning velocity of flames supported by unimolecular reactions increases until a flame limit is reached, corresponding to a situation where the hot product gases travel with a speed equal to the velocity of sound (14,15). Such low-pressure flames have very interesting properties.

Practical flame systems are supported by chains of chemical reactions and generally involve many types of free radicals or chemical intermediates. Fortunately the mathematical treatment can often be simplified by assuming that the concentrations of the free radicals or intermediates are in chemical equilibrium with the local concentrations of the fuel molecules (16,17,18,19). In such cases, the determination of the flame properties is not difficult. In any case, it is easy to show that the diffusional theories of flame propagation (requiring a migration of the free radicals from the hot toward the cold parts of the flame) (20) cannot apply.

For simplicity, we consider, in this discussion, only one-dimensional (sheets) steady-state flames. It is found that for steady-state flames a flame holder which extracts a small amount of heat from the fuel gases is necessary. The heat transfer to the flame holder determines the quenching distance or the position of the flame with respect to the flame holder.

Diffusion plays an important role in all flames. For this reason, G_i, the fraction of the mass flux due to component i, is an important variable. In terms of w_i, the mass fraction of i, and V_i, the diffusion velocity of i relative to the mass average or stream velocity v, the variables G_i are

$$G_i = w_i\,[1 + (V_i/v)]. \qquad [1]$$

The G_i are often referred to as the chemical progress variables. Usually there are as many linearly independent G_i as there are chemical reaction steps.

The basic flame equations are the equations of conservation of each chemical species, the equation of energy balance, and the diffusion equations. The equation of motion usually does not play an important role in one-dimensional flames, but simply leads to the conclusion that the pressure p remains very nearly constant throughout the flame. It follows from the equation of motion that

$$(p_0 - p_\infty)/p_0 = \gamma\, v_0(v_\infty - v_0)/c_0^2, \qquad [2]$$

where c_0 is the velocity of sound, γ is the specific heat ratio, and the subscripts 0 and ∞ are used to indicate the conditions near the flame holder and infinitely far from the flame holder, respectively. For a typical flame, $(p_0 - p_\infty)/p_0$ is of the order of magnitude of 10^{-5}. Although this minuscule pressure difference is completely negligible in the consideration of one-dimensional flames, it may play an important role in determining the shape and other properties of actual three-dimensional flames.

The overall conservation of mass leads to the conclusion that M, the total mass rate of flow, remains constant throughout the flame. Thus,

$$M = \rho v = \rho_0 v_0 = \rho_\infty v_\infty, \qquad [3]$$

where ρ is the gas density. The stream velocity near the flame holder, v_0, is the flame velocity. One of the primary objectives of the theory of flame propagation is the *apriori* calculation of the flame velocity.

The equation of conservation of the i-th chemical species is

$$M dG_i/dz = m_i K_i, \qquad [4]$$

where z is the distance from the flame holder, m_i is the molecular weight of i, and K_i is the chemical rate of formation of i in moles per unit volume.

The equation of conservation of energy may be written in the form

$$\lambda\, dT/dz = M\left[\sum_i \hat{H}_i G_i - \sum_i \hat{H}_{i\infty} G_{i\infty}\right], \qquad [5]$$

where λ is the coefficient of thermal conductivity, T is the temperature, and $\hat{H}_i$ is the enthalpy per unit mass of the i-th component.

The diffusion equations of a multicomponent mixture are

$$dx_i/dz = (M/n)\sum_j (x_i m_i G_j - x_j m_j G_i)/(m_i m_j \mathcal{D}_{ij}), \qquad [6]$$

where x_i is the mole fraction of component i, the $\mathcal{D}_{ij}$ are the

usual binary diffusion coefficients, and n is the total number of moles per unit volume.

The boundary conditions on the flame equations are conditions at the flame holder and infinitely far from the flame holder at the "hot boundary." At the flame holder, dT/dz has a predetermined value, associated with the strength of the heat sink, and the G_i are equal to the mass fractions of the various components in the incoming fuel gas. At infinity, the derivatives of all of the flame variables are zero, and complete thermal and chemical equilibrium is established.

For a particular chemical system and set of initial conditions, there is only one value of the flame velocity for which there exists a solution of the flame equations which satisfies all of the boundary conditions. Thus the flame velocity, or the mass rate of flow M, is an eigenvalue of the flame equations.

As an example, we consider a particularly simple flame in which a fuel gas A decomposes by a unimolecular chemical reaction to form a product gas B. If one molecule of A decomposes to form s molecules of B, the reaction is

$$A \longrightarrow sB.$$

The reaction rate is

$$K_A = -(\rho w_A k'/m_A)\exp(-E^*/RT), \qquad [7]$$

where k' is the steric constant and E^* is the activation energy for the reaction.

In order to simplify the equations, we take the enthalpy change (per unit mass) in the reaction

$$\hat{Q} = \hat{H}_A - \hat{H}_B, \qquad [8]$$

to be constant and assume that the heat capacity per unit mass of A is the same as that of B so that

$$(\hat{C}_p)_A = (\hat{C}_p)_B = \hat{C}_p. \qquad [9]$$

The Lewis number

$$\delta = \hat{C}_p \rho \mathfrak{D}_{AB}/\lambda \qquad [10]$$

is also taken to be constant.

It is convenient to define the reduced distance variable

$$\xi = M \int_0^z (\hat{C}_p/\lambda)dz \qquad [11]$$

and the reduced temperature

$$\theta = T/T_\infty. \qquad [12]$$

Also, we introduce the parameters

$$a = \hat{Q}/\hat{C}_p T_\infty) \qquad [13]$$

and

$$\mu^2 = (v_0^2 \rho_0^2 \hat{C}_p)/(k' \rho \lambda). \qquad [14]$$

We assume that the group $k' \rho \lambda$ is constant throughout the flame so that μ^2 is a constant.

In terms of these quantities, the flame equations are

$$dG_A/d\xi = -(w_A/\mu^2)\exp(-E^*/(RT_\infty\theta)) \qquad [15]$$

$$\delta\, dw_A/d\xi = w_A - G_A \qquad [16]$$

$$d\theta/d\xi = aG_A - (1-\theta). \qquad [17]$$

If now the Lewis number, δ, is taken to be unity (which is very nearly the case for many substances), one integral of the equations may be obtained immediately:

$$aw_A = 1 - \theta. \qquad [18]$$

This result implies that the enthalpy per unit mass of the mixture remains constant throughout the flame.

Combining Eqs. [15], [17], and [18], we find that for $\delta = 1$,

$$dG_A/d\theta = \frac{-(1-\theta)\exp(-E^*/(RT_\infty\theta))}{a\mu^2(aG_A - 1 + \theta)}. \qquad [19]$$

The problem is thus reduced to that of obtaining a satisfactory solution of this single differential equation.

At the hot boundary, $\theta = 1$ and $G_A = 0$. Thus the right side of Eq. [19] is indeterminate at this point. However, with the use of L'Hospital's rule, one finds that at the hot boundary

$$(dG_A/d\theta)_\infty = -\frac{1}{2a}\left[1 + \left\{1 + \frac{4}{\mu^2}\exp(-E^*/RT_\infty)\right\}^{1/2}\right]. \qquad [20]$$

Using Eq. [20], Eq. [19] may be integrated numerically from the hot boundary toward the cold boundary for any assumed value of μ. At the flame holder, where $\theta = \theta_0$, the value of G_A should be unity. If too large a value of μ is assumed, the numerical integration leads to a value of G_A, at θ_0, less than unity; if too small a value of μ is assumed, too large a value of G_A at θ_0 is obtained. Thus one adjusts the value of μ until the numerical integration leads to the correct value of G_A at the flame holder. Fig. 1 shows how the calculations of G_A as a function of θ depend on μ for a typical case. Once μ has been determined, the flame velocity may be calculated from Eq. [14].

The variation of the flame velocity with the heat transfer to the flame holder can be determined from a careful study of the flame equations. It is found that there is a minimum amount of heat transfer which will permit the existence of a steady-state flame. This minimum heat transfer is proportional to the chemical reaction rate in the ambient fuel gas and is so small in magnitude that it can have very little practical significance.

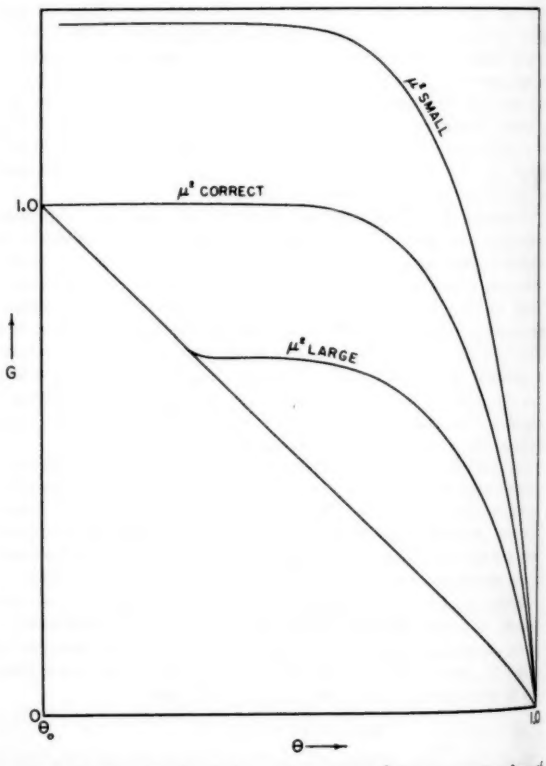

Fig. 1. Numerical solutions of G versus θ for assumed values of μ^2 in a typical case.

There is also a maximum amount of heat which can be transferred to the flame holder without extinguishing a steady-state flame. For amounts of heat transfer between these two limits, the flame velocity is double-valued, with the lower value of the flame velocity corresponding to an unstable mode of burning. Fig. 2 shows the flame velocity as a function of heat transfer to the flame holder for a typical case.

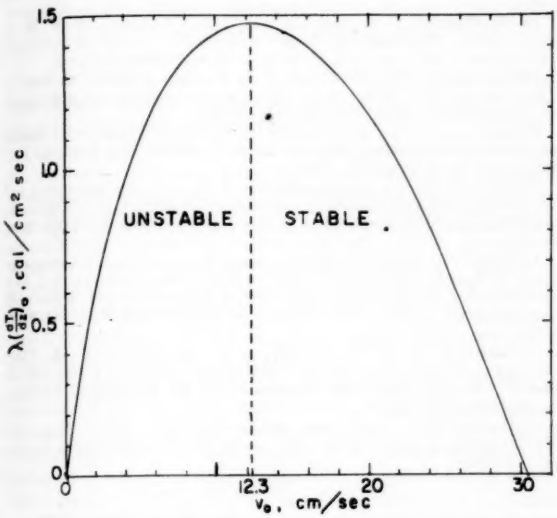

Fig. 2. The heat transfer to the flame holder, $\lambda(dT/dz)_0$, versus the flame velocity for a typical case. Note the minimum value of the flame velocity for stable flame propagation.

An interesting approximation to the flame solutions is obtained by making the "ignition temperature approximation." In this approximation, the Arrhenius temperature dependence of the reaction rate, $\exp(-E^*/(RT_\infty\theta))$, is approximated by an average value, $\exp(-E^*/(RT_\infty\theta_{av}))$, when the reduced temperature is above a reduced ignition temperature, θ_i, and by zero when the reduced temperature is less than θ_i. For a typical case it was found that the ignition temperature solution has the same flame velocity and same "flame thickness" as the numerical solution using the Arrhenius kinetics if $\theta_i = 0.77$ and $\theta_{av} = 0.89$. In order to obtain the ignition temperature solutions, it is convenient to let

$$\Phi = \mu^{-2}\exp[-E^*/(RT_\infty\theta_{av})] \qquad [21]$$

$$\alpha = (2\delta)^{-1}[-1 + (1 + 4\delta\Phi)^{1/2}] \qquad [22]$$

and take $\xi = 0$ at the ignition temperature. Then it is easily shown that the ignition temperature solution of the flame equations for an arbitrary value of the Lewis number δ is:

(1) in the high temperature range, $\theta > \theta_i$ and $\xi > 0$,

$$G_A = \exp(-\alpha\xi) \qquad [23]$$

$$w_A = (\alpha/\Phi)\exp(-\alpha\xi) \qquad [24]$$

$$\theta = 1 - [a/(1+\alpha)]\exp(-\alpha\xi) \qquad [25]$$

(2) in the low temperature range, $\theta < \theta_i$ and $\xi < 0$,

$$G_A = 1 \qquad [26]$$

$$w_A = 1 - [1 - (\alpha/\Phi)]\exp(\xi/\delta) \qquad [27]$$

$$\theta = (1-a) + (\theta_i - 1 + a)\exp(\xi) \qquad [28]$$

The eigenvalue, Φ, is determined by the condition of continuity of the solutions in the two regions.

If the heat transfer to the flame holder is small

$$a = 1 - \theta_0 = \hat{Q}/(\hat{C}_p T_\infty) \qquad [29]$$

and

$$\Phi = (\theta_i - \theta_0)[1 + (\delta - 1)\theta_i - \delta\theta_0](1 - \theta_i)^{-2}. \qquad [30]$$

Then from Eqs. [14] and [21], we obtain an expression for the flame velocity:

$$v_0 = \{[\lambda_0/(\hat{C}_p\rho_0\Phi)]k'\exp[-E^*/(RT_\infty\theta_{av})]\}^{1/2} \qquad [31]$$

This result, in agreement with all treatments of flame propagation, indicates that the flame velocity is proportional to the square root of the reaction rate. It is interesting to note that diffusion in simple flames decreases the flame velocity, since it has the effect of diluting the reacting gas. For a typical case, with $\theta_0 = 0.15$ and $\theta_i = 0.77$, Eq. [30] gives $\Phi = 10.0$ if $\delta = 1$. If the diffusion coefficient were zero, so that $\delta = 0$, Eq. [30] would give $\Phi = 2.7$. Thus the flame velocity in a system with no diffusion would be almost twice as large as the flame velocity in a system with a reasonable coefficient of diffusion.

The great majority of flames which have practical interest involve complicated sets of chemical reactions or reaction chains. Such systems would be extraordinarily difficult to treat. However, in most flames it is a good approximation to assume that the free radicals and other chemical intermediaries have pseudo-stationary concentrations so that the complicated chain of reactions can be treated as though there were only a single step of chemical reaction. It may easily be shown that, in the hottest part of a flame (where most of the reaction takes place), the free radicals are diffusing away from the flame holder so that the purely diffusional theories of flame propagation cannot be true.

The theory of flame propagation presented here represents the first step in the consideration of practical systems. Future steps will involve generalizations to nonstationary states and to three dimensions. Eventually, the treatment should consider radiative transfer and turbulence.

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Analytical Methods in Applied Mechanics

(See also Revs. 1602, 1606, 1607, 1611, 1624, 1638, 1661, 1663, 1665, 1678, 1689, 1822, 1852, 1939, 2032, 2085, 2093)

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Authors give first a short and conformable algorithm for the inversion of the matrices belonging to a rectangular network. Afterwards, a method of reduction in order to obtain the inverse matrix belonging to an arbitrary network has been developed. Several numerical examples having matrices of small orders illustrate the methods, which are appropriate for machine computation.

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The approximate solution of the differential equation $x_{tt} + 2mx_t + nx = 0$, where $m = m(t)$, $n = n(t)$, is treated by Liouville, Collar, Wentzel, Kramers, Brillouin (known as WKB approximation), Imai. Many extensions of the approximation have been developed recently (Bailey, Dingle, Hecht, Mayer). This note is based on the extension due to Bailey. This approximation can be developed from the equivalence of the above equation and the Riccati equation, $w^2 + w_t + 2mw + n = 0$, where $w = x_t x^{-1}$; $w_t = Dw$, so that $x = C(\exp \int mdt)$ in the form $D \simeq f^{-1} Df$, where $f = f(m,n)$. The method of eliminating the first derivative from the governed equation is used, and the invariant of the differential equation $I(t) = n - m_t - m^2$ is introduced. The obtained results are discussed. Author concludes that these approximate methods are useful tools and offer a field for further study in the theory of higher-order equations.

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Author considers the following problem: Determine the velocities of points of a fluid enclosed by two pulsating concentric circular cylindrical surfaces. It requires the solution of a certain hyperbolic partial differential equation subject to initial and nonhomogeneous boundary conditions. After transforming the given problem into one involving homogeneous boundary conditions separation of variables leads immediately to a Sturm-Liouville system with an

orthogonal set of eigenfunctions. The author first develops the general theory of such a differential equation and then applies it to his particular problem. In this case the Sturm-Liouville system is a system of ordinary Bessel differential equations.

J. Lense, Germany

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Book—1588. Sasieni, M., Yaspan, A., and Friedman, L., Operations research—methods and problems, New York, John Wiley & Sons, Inc., 1959, xi + 316 pp. $10.25.

This book is a welcome addition to the growing list of books on the subject of Operations Research. The authors state that much of the subject matter arose out of a problems course in operations research, designed as a companion course to the general methods course offered at Case Institute of Technology. It is the reviewer's opinion that this book does fill the need for a textbook at an elementary level. The general theory is explained in a very simple and clear manner, a number of illustrated problems are completely developed, and there are a large number of problems for the reader to solve—some with answers.

The chapters are organized in the following manner: Probability, Sampling, Inventory, Replacement, Waiting lines, Competitive strategies, Allocation, Sequencing, and Dynamic programming. As might be expected for a book covering a wide scope in only 300 pages, each subject is covered superficially rather than in depth. On the other hand references are provided at the end of each chapter for the use of the more serious student.

Reviewer is very happy to recommend this book as an elementary text on Operations Research. J. S. Aronofsky, USA

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Paper reviews past developments of a basis for "reliability" as an evaluation factor along with "inherent accuracy." Method of zero failure probability is described and evaluated. Approach by Brown is discussed and an alternative related method suggested. Analytical aspects of this method for describing system performance in terms of both reliability and accuracy are treated. Generalized probable error is chosen as a measure of system performance. General characteristics of solution for this measure are found. Upper and lower bounds independent of the precise forms of the accuracy and reliability distribution functions are discussed. Concepts of "failed error" and "effective reliability" are introduced and elaborated. Numerical results are given for special case of circular normal distribution.

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Volume is the second edition of part two of the authors' "Table of Integrals." Part one contains indefinite integrals, part two definite integrals. Both parts are very complete and carefully checked for accuracy and will be useful in the practical work of mathematicians, physicists, and engineers. There is an explanation of all symbols and notation used, as well as a survey, written in German, of general methods of evaluating definite integrals. In subsequent chapters integrals of rational functions, orthogonal polynomials, integrals of algebraic irrational functions, of elementary transcendental functions, Eulerian integrals, and integrals of cylinder functions are considered. All formulas are clearly written; in the case of parameters the range of validity of the results is given, and where it is of interest we find hints for obtaining the formulas.

As in the second edition of part one, the second edition of part two contains only a few slight changes from the first edition.

R. Albrecht, Germany

1592. Gayen, A. K., and Roy, G. C., On auto-correlations of harmonic functions, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Kharagpur, Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., 1957, 345–350.

Computing Methods and Computers

(See Revs. 1584, 1610, 1631, 1678, 1703, 1942, 2032)

Analogies

(See also Revs. 1610, 1616, 1640)

1593. Boscher, J., Solution of fourth-order partial differential equations occurring in different elasticity problems with the help of electric analogies (in French), Publ. Scient. Tech. Min. Air, France no. 348, 130 pp., Dec. 1958.

The analogy between the "superposed networks" (two electric resistance networks interconnected at the corresponding joints by linking resistors) and the finite difference solution of certain fourth-order partial differential equations in two variables is presented.

The equipment and instrumentation used are described in detail and a number of applications of the analogy, i.e.: Airy function solution of elastostatic problems for simply and multiply connected domains, analysis of plates with various load and edge conditions, natural modes of plates and membranes, etc., are worked out and the experimental results shown to be in good agreement with the known theoretical solutions.

E. Saleme, Argentina

1594. Baehr, H. D., and Schubert, F., Determination of the efficiency of quadratic plate-type fins by means of an electrical analogy method (in German), *Kältetechnik* **11,** 10, 320–325, Oct. 1959.

The efficiency of quadratic shaped fins, which are fixed on tubes with circular cross section, is determined by means of an electrical analogy model. The fin efficiency η_R depends on the ratio b/d where b is the length of the sides of the square and d the tube diameter. The ratio b/dk has been varied from 1.25 to 4.0. The accuracy of the applied analogy method seems to be better than 1%. From authors' summary

1595. Follinger, O., and Seifert, W., Structural diagrams—a short-cut to analog computer circuits, *Control Engng.* **6,** 7, 81–83, July 1959.

1596. Piquemal, J., The investigation by electrical analogy methods of pressure surges set up in a penstock by a periodic disturbance at the downstream end (in French), *Houille Blanche* **13,** B, 767–774, Dec. 1958.

Paper describes an electrical analogy of the unsteady flow which originates in a penstock of uniform characteristics by periodic disturbances at the downstream end (for instance as a con-

sequence of the passage of the runner vanes of a turbine before the guide vanes); an apparatus (analogic simulator) was designed and constructed to test the analogy.

Results, both qualitative and quantitative, are in very good agreement with those obtained recently by Escande by means of the Bergeron graphical method.

In the discussion following the presentation of results the different methods actually useful for the study of such phenomena are recalled and compared. D. Citrini, Italy

1597. Patigny, J., Study of mine ventilation with the help of electrical analogy (in French), *Rev. Univ. Mines* (9), **14,** 11, 381–416, Nov. 1958.

Essentially, paper concerns investigation of ventilation of mines through use of resistance network simulator. Following introduction regarding essentials of interest, fundamental laws of flow of fluids in a ventilation network are reviewed; the incompressible and compressible cases are considered in succession. Subsequently, analytic and graphic methods of simplifying are reviewed. Next, analytic calculation of distribution of air in the simplified network by an iterative procedure is outlined. In turn, solution of the system of equations by electric network simulator comprised of electric resistors is summarized: for resistors comprised of incandescent lamps, of automatically varied resistors, or of manually varied resistors. Finally, the construction, operation, and use in practice of a newly constructed electric analog with variable resistors is detailed. General remarks, glossary, and a list of 16 references, chiefly to European literature, conclude the paper.

It is clearly written, thorough in coverage, illustrated by several figures detailing the new table, and cites a number of references probably not well-known in U.S. It can be read with interest and profit by all concerned with electric analog simulation and/or mine ventilation. T. J. Higgins, USA

1598. Nash, W. A., and Hijab, W. A., Analog determination of generalized shock spectra, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 27–36, 1958.

Authors describe analog computer for determining a modified shock response spectrum giving "equivalent" acceleration factor accounting for the fatigue effect produced by the sequence of acceleration levels in response to a system of series of shock loads. The equivalence is based on Miner's, ["Cumulative damage in fatigue," *J. Appl. Mech.* **13,** p. A-159, 1945] hypothesis that fatigue damage is proportional to cumulative cycle ratio.

N. M. Newmark, USA

1599. Blass, E., and Wesser, U., Direct current network for an analogy model of refrigeration machinery and equipment (in German), *Kältetechnik* **11,** 10, 326–331, Oct. 1959.

The knowledge of steady working conditions as they occur, for example, in refrigerating engineering may be gained by the application of direct current networks. In the present paper some electrical analogy methods are described. For a direct current network of widely different applications the necessary programming work as well as the accuracy obtainable is discussed.

From authors' summary

1600. Stephenson, D. G., and Starke, G. O., Design of a π network for a heat-flow analog, *ASME Trans.* **81** E (*J. Appl. Mech.*) 2, 300–301 (Brief Notes), June 1959.

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 1619, 1623, 1624, 1790, 1804, 1810, 2032, 2036, 2040, 2043, 2044, 2108, 2116)

1601. Kirgetov, V. I., On transpositional relations in mechanics, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22,** 4, 682–693, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

The well-known transpositional relations warranting the unrestricted validity of Hamilton's principle in the case of holonomic systems may fail to hold for all coordinates if one has to do with nonholonomic systems.

The paper in question considers a mechanical system subjected to certain linear differential constraints. Having introduced the notion of kinematically admissible motions of the system, author first proves a lemma on complete integrability of the equations of constraints in the case of a kinematically admissible motion. The second part introduces a special operation applicable to functions of coordinates and time which are differentiable with respect to time and examines whether it satisfies certain transpositional relations. The question is solved by establishing a necessary and sufficient condition for the validity of such relations.

An example illustrates theoretical deductions which are to be considered as a valuable contribution to the important question whether and in what measure one can extend the already known theorems for holonomic systems to the case of nonholonomic ones. The reading of the paper presupposes adequate knowledge in higher mathematics. V. Vodicka, Czechoslovakia

1602. Gold, L., A reduced solution for the simple pendulum: New approach to elliptic functions, *J. Franklin Inst.* **267,** 6, 503–509, June 1959.

Author notes that if $\tau = f(\phi)$ is a solution of the standard pendulum equation $d^2\phi/d\tau^2 = -\sin(\phi - \theta_0)$, then $f''(\phi) + \sin(\theta_0 - \phi) \times [f'(\phi)]^3 = 0$. For the initial conditions of the pendulum problem, this equation has a series solution of the form $\Sigma a_{n+1}\phi^{n+\frac{1}{2}}$, where the coefficients a_{n+1} are determined by equating coefficients. The relation of such a power series and conventional elliptic integrals is pointed out and a simple expression obtained, in terms of them, for the period of a pendulum, but the properties of the functions defined in this way are not further investigated and no numerical values are discussed. I. N. Sneddon, Scotland

1603. Ioanno, D. K., The stability of the free oscillations of a Poshekhonov round pendulum (in Russian), *Trudi Saratovsk. S.-kh. In-ta* **10,** 407–413, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12091.

A mechanical system with two degrees of freedom is examined; author gives this the name of Poshekhonov's round pendulum. For the first approximation it is assumed that one of the coordinates changes proportionally to time; after this, the second equation assumes the form of a heterogeneous linear equation with periodic coefficients. The stability of the zero solution is looked into; this corresponds to the homogeneous equation arrived at by the Lyapunov and the Zhukovskii methods.

G. K. Pozharitskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1604. To, K.-L., Determination of the dynamical characteristics of a linear system by means of spectral functions, *Scientia Sinica* **8,** 6, 643–649, June 1959.

Paper outlines a method for determining the dynamical characteristics of a linear system which is based on the statistical analysis of random variations of the input and the output quantities. The application of the method can be made under normal operating conditions without interrupting the operation of the system or subjecting it to unusual disturbances. It is shown that if the spectral functions of quantities at the input and at the output are known, any element of the transfer matrix of the system can be determined by solving $(i \times n)$ simultaneous linear equations.

It is also shown that the spectral functions can be determined experimentally. One divides first a spectral function into two parts; one part with poles in the upper half plane and the other in

the lower half plane of the complex plane. Then each part is approximated by a sum of orthogonal functions with complex arguments; their coefficients are determined by a special electronic device.

The paper is illustrated by examples.

N. Minorsky, France

1605. Sergeev, V. I., On a method of amplitude analysis in auto-oscillations (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 90–93, July 1958.

The purpose of paper is to determine the amplitude of an oscillating follow-up system containing nonlinear elements. Two cases are considered: (a) auto-oscillation; (b) auto-oscillation combined with a nonperiodic forcing term. The case (a) is studied in connection with two subcases: (a_1) nonlinearity arises from the presence of a dead zone and (a_2) nonlinearity is of a saturation type (approximation by "broken" characteristics). The method of equivalent linearization is used. The values of equivalent parameters are replaced into the differential system written in the usual operational form after which p is replaced by $j\omega$ and the real (X) and the imaginary (Y) parts are separated and ω is eliminated between X and Y; this yields the linearized expression $q(a)$ for amplitude a. Replacing this expression into the differential equation (in the operational form) one obtains equation between $q(a)$ and other parameters; in order to get the amplitude a it is necessary to use a graphical procedure. For (a_2) the procedure is the same but for a different nonlinear function.

In the case (b) the procedure is slightly different: the solution is sought in the form of two terms: one of them corresponds to auto-oscillation and the other to the nonperiodic excitation; the method of equivalent linearization is then applied to the sum of these two terms; the rest of the procedure is the same as in cases (a_1) and (a_2).

N. Minorsky, France

1606. Dimentberg, F. M., Complex representation on the phase plane of motion of a system with two degrees of freedom (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 97–99, May 1958.

Paper presents a method for phase representation of motion of a two-degree-of-freedom system in x, y, $\dot{x}$, $\dot{y}$ coordinates by means of a four-dimensional linear phase space projected on a plane. Employed are complex coordinates of motion $x + \omega\dot{x}$, $y + \omega\dot{y}$ (where ω is an operator with a property $\omega^2 = 0$) represented by the corresponding complex coordinates of a straight line, and an equation is derived for a phase "curve" in complex form.

From author's summary by V. Chobotov, USA

1607. Aizerman, M. A., and Gantmakher, F. R., On the stability of periodic motions, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22,** 6, 1065–1078, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

The present paper is wholly mathematical. Let $z_0(t)$ be a periodic solution of period τ of the vector system [1] $x' = f(z,t)$ where f has period τ in t. When $f(z,t)$ is continuous and sufficiently differentiable, the solution $z_0(t)$ is asymptotically stable if all of the characteristic multipliers of the variational system [2] $x' = f_x[z_0(t), t]\,x$ have absolute value less than 1. In the autonomous case, where f does not depend on t, one of the characteristic multipliers is equal to + 1; the solution is asymptotically orbitally stable if the remaining $(n-1)$ characteristic multipliers have absolute value less than 1. If any characteristic multiplier of [2] has absolute value greater than 1, $z_0(t)$ is unstable. These well-known results are extended by the authors to the case that $f(z,t)$ has certain surfaces of discontinuity, but is smooth between them. Such systems occur in discontinuous automatic control problems.

W. S. Loud, USA

Instrumentation and Automatic Control

(See also Revs. 1982, 2097)

1608. Eklund, K., A graphic solution for the damping of cubic systems, *Control Engng.* **6,** 6, p. 111, June 1959.

A chart gives the damping factor and undamped natural frequency of systems described by a cubic characteristic equation. These factors can be used with published charts for quadratic systems to determine the response of the cubic system to various transient inputs.

From author's summary

1609. Valstar, J. E., How to reduce interaction between control loops, *Control Engng.* **6,** 6, 112–113, June 1959.

Control can often be improved, with no extra equipment and with just a few minutes' test or analysis, simply by making sure that the controllers link the best combination of measured variable and final control element. By means of simple procedures, interacting control loops can be made more independent. The ideas can be applied to any controlled system in which a change in one final control element causes a disturbance in another loop.

From author's summary

1610. Basu, S. K., On the determination of transient response of linear systems, *J. Sci. Indust. Res., India* **18**B, 3, 93–96, Mar. 1959.

Transient response of a complicated linear network is computed by means of a mixed method: first, one assumes zeros and poles are known; then, inverse Laplace transform requires the knowledge of coefficients that are calculated from the zeros and poles. Author suggests two analog methods for their computation by means of an electrolytic tank.

J. M. Loeb, France

1611. Yakubovich, V. A., On the stability, taken as a whole, of the undisturbed motion for the equations of an indirect automatic control (in Russian), *Vestn. Leningrad In-ta* no. 19, 172–176, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12082.

An examination is carried out of a system of equations for an indirect control

$$\frac{dx}{dt} = Ax + a\varphi(\sigma), \quad \frac{d\sigma}{dt} = (b, x) - \sigma\varphi(\sigma) \qquad [1]$$

where (x, a, b) are vectors, A is a matrix of the nth order. The following theorem is argued: If in system [1] $\operatorname{Det} \| A \| \neq 0$, $\varphi(\sigma)$ is a continuous function ($\varphi(0) = 0$ and $\sigma\varphi(\sigma) > 0$ when $\sigma \neq 0$) and if for the system [1] a function can be found having Lyapunov's form

$$V = -(Hx, x) - \int_0^\sigma \varphi(\sigma)\,d\sigma$$

the derivative of which on the strength of [1] has the form

$$\dot{V} = (Gx, x) + [(g, x) + \sqrt{\rho}\,\psi(\sigma)]^2 ((Hx, x) > 0, (Gx, x) > 0)$$

then the trivial solution of system [1] is fully stable.

B. S. Razumikhin

Courtesy Referativnyi Zburnal, USSR
Translation, courtesy Ministry of Supply, England

1612. Schmidt, S. F., The analysis and design of continuous and sample-data feedback control systems with a saturation type nonlinearity, NASA TN D-20, 106 pp., Aug. 1959.

Report deals with "switch time method" of designing feedback control systems with a single-saturation-type nonlinearity. The "switch time method" is based on an approximation of the classical optimum bang-bang solution for a step function input. The con-

cept of a root locus with the saturation nonlinearity represented by variable gain is also treated. Report includes both sampled-data and continuous systems. V. B. Haas, Jr., USA

1613. Cypkin, Ja. Z., On the relationship between the characteristic line of a nonlinear element and its describing function (in German), *Regelungstech.* **6,** 8, 285–287, Aug. 1958. (Translation of *Automatika i Telemekhanika* **17,** 343–346, 1956).

By the use of an approximate method of integration due to Steklov author shows that the describing function $S(A)$ can be expressed in the form $S(A) = (2/3A)\,[F(A) + F(A/2)]$. The expression is exact when the nonlinear relation $F(A)$ is expressible in the form of a polynomial of degree not higher than 5. A better approximation is also given, together with a related method, for the converse problem of deducing the nonlinear characteristic from the describing function. G. D. S. MacLellan, Scotland

1614. Bedel'baev, A. K., Stability of non-linear control systems (in Russian), *Izv. Akad. Nauk KazSSR, Ser. Matem. i Mekhan.* no. 6(10), 51–59, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12085.

The problem is investigated of the stability in a large system of autocontrol with variable coefficients. Some results obtained by N. G. Chetaev and N. D. Moiseev are discussed; these relate to the problem of stability of linear systems with variable coefficients. Lyapunov's function of known form

$$Q + \int_0^{\sigma} f(\sigma)\,d\sigma$$

is proposed for the solution of the problem. In this case Q is the quadratic form of Lyapunov's functions for a system with a disconnected servomotor constructed according to the method developed by N. G. Chetaev. The paper is barren of new results and contains no references to the essential literature on the subject.

B. S. Razumikin

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

1615. Pun, L., Considerations on the simulation of certain industrial systems with the help of small electric motors. Parts I, II, III (in French), *Automatisme* **3,** 10, 380–384, Oct. 1958; **3,** 12, 461–468, Dec. 1958; **4,** 1, 14–17, Jan. 1959.

1616. Santuz, G., Use of process simulator in study of control circuits (in Italian), *Termotecnica* **13,** 4, 159–168, Apr. 1959.

1617. Togino, K., Analysis of electronic servosystem adapted to numerically controlled machine tool, Part I, *J. Mech. Lab., Tokyo* **4,** 2, 60–68, 1958.

1618. Togino, K., Analysis of electronic servosystem adapted to numerically controlled machine tool. Part II, A theoretical analysis of dynamic characteristics of D. C. shunt servomotor driven by grid controlled thyratron amplifier, *J. Mech. Lab., Tokyo* **5,** 1, p. 68 (Abstracts), 1959.

1619. Colombo, G., Theory of Bouasse and Sarda's regulator (in Italian), *R. C. Semin. Mat. Univ. Padova* **28,** 2, 338–347, 1958.

This paper concerns a mechanical system composed of a shaft with a pulley on which a weight is suspended. A second weight constrained moves in a vertical line connected by a spring to a crank on the shaft, this weight being suspended from the crank. Friction effects are included. This is a problem in two degrees of freedom. The differential equations of motion for the shaft angle and the coordinate of the spring-supported weight are derived, and properties of the solution of the system, when disturbed, are obtained. This is accomplished through a standard technique of introducing a parameter. Necessary and sufficient conditions are derived for the existence of the jump phenomenon.

R. Oldenburger, USA

1620. Murtaugh, S. A., Jr., An introduction to the time-modulated acceleration switching electrohydraulic servomechanism, *ASME Trans.* **81**D (*J. Basic Engng.*), 2, 263–271, June 1959.

Paper is discussion of new ideas in electrohydraulic control. The usual hydraulic servomechanism design uses a d c amplifier and flow-control to obtain flow proportional to position or velocity error of the load. In the acceleration switching servo these components are replaced by a multi-vibrator and a specially designed electrohydraulic servo valve called an AS valve. System control is obtained by modulation of the multi-vibrator square wave dwell time (duty cycle) by which the load acceleration is regulated. Author claims that this valve acts as a pure integrator through most of its operating frequency range, and that use of this technique results in increased reliability, excellent valve resolution, negligible center shift due to temperature extremes and near infinite pressure-gain characteristics.

Author's claims appear well substantiated by the work and conceptual activity described in the paper, with the exception that the valve transfer function is later shown to be a first-order lag rather than an integration.

This reviewer feels it unfortunate that nothing was mentioned of the use of the AS valve with compressible media (in electropneumatic servos) where, it is felt, its potential will be appreciated even more than in the hydraulic. The advent of this valve makes it possible now to design a high-response pneumatic servo operating at fluid temperatures of from −300 F to +800 F.

Much excellent discussion is included, the majority of which supports the author's views. C. C. Osgood, USA

1621. Krassov, I. M., and Turbin, B. G., Concerning a possibility of determining an axial hydrodynamic force in a valve, *Automation and Remote Control* **19,** 3, 210–213, Feb. 1959. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 3, 217–221, Mar. 1958 by Instrument Society of America, Pittsburgh, Pa.)

Paper deals with an axial hydrodynamic force that appears in valve hydraulic amplifier when the working liquid flows through it. The amplifier described may be a meter of the force. Experimental results are presented. From authors' summary

1622. Rumiantsev, V. V., On the stability of motion of a gyroscope on gimbals, Parts I and II, *Appl. Math. Mech. (Prikl. Mat. Mekh.),* **22,**3, 513–529, 1958; **22,** 4, 694–700, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

The analysis of the stability problems of a symmetrical gyroscope on gimbals begins with the case in which frictional forces of the gimbal axes are absent and only the influence of the gravitational forces of the gyroscope and of the gimbal rings is taken into account. The Lyapunov function follows by combining the first integrals of the equations of motion and from this the Lyapunov stability theorem gives a sufficient condition for the stability of the regular precession of the gyroscope. Then comes the investigation of the influence of frictional forces which are time derivatives of a Rayleigh function. In this case one can arrive at an asymptotically stable motion of the gyroscope.

The second part is a continuation of the preceding considerations. It examines, in the first place, the stability of a special kind of rotation of gyroscopes about vertical axes when the middle plane of the outer ring is horizontal. Using the first integrals of the equations of the perturbed motion enables the author to give a detailed analysis of the stability conditions. Special attention is paid to the gyroscopic stabilization of the motion in the case of instability. One comes to a temporary stability which is always sooner or later destroyed by the dissipative forces.

Another interesting case relates to a gyroscope whose axis is under the influence of a moment of external forces which is a continuous function of the Eulerian angles and their time derivatives.

The importance of the above deductions does not need to be emphasized in our time of the rocket flight. Apart from special knowledge in the field of stability of motions the reading presupposes an adequate experience in handling mechanical problems by use of the Lagrangian generalized coordinates.

V. Vodicka, Czechoslovakia

1623. Ishlinskii, A. Iu., On the theory of complicated systems of gyroscopic stabilization, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22,** 3, 493–512, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Equations of motion of a complicated gyroscopic device can be obtained in a relatively simple way by a successive application of principle of angular momentum to corresponding mechanical system as a whole and to its separate parts. Description of an appropriate method for case of a particular system of regulated stabilization constitutes basic contents of present paper.

W. J. Worley, USA

1624. Arkhangel'skii, Yu. A., Motion of a fast gyroscope of Goriachev-Chaplygin (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 122–124, July 1957.

Equations of motion are written for a very high-speed gyroscope of the Goriachev-Chaplygin type. Arbitrary initial conditions are assumed along with the necessary conditions that

$$A = B = 4C, \; x_0 \neq 0, \; y_0 = z_0 = 0$$

$$4(p\gamma + q\gamma') + r\gamma'' = 0$$

where

$$p = \omega a, \quad q = \omega b, \quad r = \omega c$$

$$\gamma = \gamma_0, \quad \gamma' = \gamma_0', \quad \gamma'' = \gamma_0''$$

and a, b, c, are initial direction cosines of the angular velocity ω satisfying the following relations:

$$\gamma_0^2 + \gamma_0'^2 + \gamma_0''^2 = 1, \quad a^2 + b^2 + c^2 = 1.$$

Various special cases are discussed and reference is made to similar analyses by other authors.

From author's summary by V. Chobotov, USA

Tables, Charts, Dictionaries, etc.

(See also Rev. 1926)

Book—1625. Huschke, R. E., edited by, Glossary of meteorology, Boston, Mass., American Meteorological Society, 1959, viii + 638 pp.

The *Glossary of Meteorology* purports to define every important meteorological term likely to be found in the literature today. It attempts to present definitions that are understandable to the generalist and yet palatable to the specialist; and it intends to be a reference book that satisfies its user in a minimum of his time.

Each definition represents the efforts of three or more individuals, at least two of whom are specialists in the subject area involved. A few ground rules were set down in order to unify production effort; mathematics would not be used as a substitute for verbal explanation; the first one or two sentences should be able to stand alone as a basic definition; the definitions should be understandable to an undergraduate in a technical college yet contain sufficient pertinent detail to satisfy the working specialist. It is a glossary of United States usage primarily, but definitions and terms used mainly in other countries are frequently cited.

Any reference book must provide adequate information with a minimum of effort and time required of its user. This glossary has been edited with that principle uppermost in mind. It consists of an alphabetical list, as complete as possible, of words and short phrases as they naturally appear in the literature.

In general, terms that are purely mathematical, physical, chemical, electronic, biological, etc., are not included. Some exceptions have been made in the case of very frequently used terms, where a brief description is given to provide orientation as to area of reference of the term.

It is recognized that literature references are incomplete within this volume. Only those references are listed that were initially submitted by the many contributors. However, readers are referred to documentation of the rapidly swelling volume of the world's important literature in meteorology and related fields that is provided by *Meteorological Abstracts and Bibliography.*

As of date of publication, the *Glossary of Meteorology* is reasonably up-to-the-minute. With every month, however, the growth of this science expands its vocabulary. It is hoped that this volume provides a sound basis for a continuing record of the meteorologists' language, just as it documents today's terminology and places it within the grasp of every worker in the field.

From author's preface

Book—1626. Eichner, H., and Hein, H., Reading German for scientists, New York, John Wiley & Sons, Inc., 1959, xi + 207 pp. $5.25.

Elasticity

(See also Revs. 1593, 1652, 1668, 1680, 1689, 1691, 1706, 1730, 1734, 1798, 1808, 2062)

Book—1627. Flugge S., edited by, Encyclopedia of physics, Vol. 6, Elasticity and plasticity [Handbuch der Physik, Band VI, Elastizitat und Plastizitat], Berlin, Springer-Verlag, 1958, vii + 642 pp. DM 145.

This volume consists of six independent parts. All parts are written in English.

I. The classical theory of elasticity, by I. N. Sneddon and D. S. Berry (126 p.).

Authors emphasize that they have confined themselves to certain parts of the basic theory of elasticity. For omissions such as the theory of elastic stability and elasticity they refer to other textbooks. The first chapter deals with the analysis of strain, the analysis of stress and the stress-strain relations. The analysis of strain is based on the theory of large deformations, which makes this part more difficult to read than the other chapters of this part, where all strains are assumed to be infinitesimal. The second chapter presents the theory of cylindrical bodies under constant torsional and bending moments. The third chapter deals with plain stress and plain strain problems in terms of complex stress functions (Mushkelishvili), with Cauchy integral methods and integral transform methods. In the fourth chapter attention is paid to three-dimensional problems and stress functions to be used therewith. Only little is said about rotatory symmetrical stress distributions. The last two chapters are on elastic waves and thermoelasticity.

II. Photoelasticity, by H. T. Jessop (102 p.).

This part is a comprehensive article on the present state of photoelastic techniques. It starts with some interesting pages on the history of the subject. The main subjects are the optical basis, photoelastic equipment and materials, two-dimensional stress systems, three-dimensional stress systems with the aid of freezing techniques and practical applications. Under the head "future developments," attention is drawn to the plastic region and dynamic stresses.

III. The mathematical theories of the inelastic continuum, by A. M. Freudenthal and H. Geiringer (205 p.).

The part by Freudenthal is concerned with the viscoelastic, plastic and viscoplastic flow and starts with thermodynamic considerations. Attention is given to variational principles. In the discussion of plastic deformation only little attention is paid to the anisotropic hardening of strained metals which, for example, gives rise to the Bauschinger effect. In the part by Geiringer the theory of the stress distribution in bodies, partly in an elastic, partly in a plastic state, is given. The material has a fixed yield limit (von Mises' yield condition) and does not show strain hardening. Among the applications are torsion, expansion of thick-walled tubes, loaded wedges and plastic masses between rough plates.

IV. Reology, by M. Reiner (117 p.).

This is a thorough discussion of the rheological phenomena. The principal sections are on classical bodies (Hookean solid, Newtonion liquid, Kelvin solid, Maxwell liquid, Prandtl-Reuss plastic solid; the discussion is elucidated by means of mechanical models), macrorheology, microrheology, physical and geometrical nonlinearity and rheometry.

V. Fracture, by R. Irwin (40 p.).

This part starts with theoretical considerations on the tensile stress of liquids. Elastic stress distributions around cracks and propagations of cracks are analyzed. An analysis of the effects of size upon fractioning is given.

VI. Fatigue, by A. M. Freudenthal (23 p.).

This seems to the reviewer to be a well-balanced summary on the subject. It may also serve as a guide to the given 39 references.

It could hardly be avoided that in the parts, written by different authors, some minor duplications occur, such as the analysis of strain of some considerations in the parts "Inelastic continuum" and "Rheology." This cannot be called a drawback, as the different parts can be read independently.

There is an English and a German subject index for all parts. As normal with books of this editor, the make-up of the book is very good. This volume of the Encyclopedia of Physics, written by prominent authors in their field, gives a lot of information and shows the way to other sources. It should be on hand at any research institute involved in elasticity and plasticity problems.

J. P. Benthem, Holland

1628. Pelczynski, T., On Mohr's strain hypothesis (in German), *Maschinenbautechnik* **8**, 5, 251–254, May 1959.

Author points out that Mohr's envelope criterion for critical states of plasticity and fracture is now out of date since plasticity and fracture are essentially different phenomena which cannot be represented by a single curve in a normal stress shear stress diagram but would be represented by different areas in such a plot. Papers by Leon and Slattenschek (1933, 1939, 1951) come in for particular—in this reviewer's view perfectly justified—criticism. Author perhaps tilts at windmills since Mohr's envelope criterion in any case is no longer taken seriously. R. Weck, England

1629. Jain, M. K., Problems of cross-elasticity, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Kharagpur, Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., 1956; 81–86.

Paper concerns Reiner's theory of cross elasticity, a special case of general elasticity which differs from Seth's theory of finite elasticity by addition of a second-order term. Problems of simple tension, hydrostatic pressure and longitudinal vibrations are solved. Yield stress is shown to depend on Young's modulus and coefficient of quadratic term, or coefficient of cross elasticity. In case of longitudinal vibration, forces arising from quadratic term (cross elastic forces) damp propagation of waves.

B. Bernstein, USA

1630. Ufland, Ia. S., Mixed boundary value problem for an elastic lamina, *Soviet Phys.-Doklady* **3**, 6, 1297–1299, June 1959. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **123**, 6, 991–993, Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author gives an exact solution of the three-dimensional problem for an unbounded lamina ($-\infty < x, y < \infty$, $0 \leq z \leq b$), assuming that on one of its bounding planes the displacements (u, v, w) are assigned, and on the other, the stresses (σ_z, τ_{zx}, τ_{zy}). Proceeding from the representation of displacements by the four harmonic functions (ϕ_0, ϕ_1, ϕ_2, ϕ_3) of Papkovich and Neuber, ϕ_1 and ϕ_2 are readily determined in compliance with the boundary conditions and the mixed boundary conditions are then deduced for ϕ_0 and ϕ_3 whose solutions are found in the form of Bessel functions. Paper closes by exemplifying the case of a lamina with a fixed base, deformed by a tangential force applied at a point on the opposite bounding plane. C. S. Pelecudi, Roumania

1631. Cunningham, C. W., Graphical integration aids deflection calculations by virtual work, *Civ. Engng.* **29**, 3, p. 61, Mar. 1959.

1632. Diaz, J. B., and Payne, L. E., On a mean value theorem, and its converse, for the displacements in the theory of elasticity, AFOSR TN 59-212 (Univ. Maryland, Inst. Fluid Dynamics & Appl. Math., TN BN-161; ASTIA AD 211 666), 7 pp., Jan. 1959.

The displacement components in the theory of elasticity obey a certain mean value theorem which is the analog of Gauss' mean value theorem in potential theory. This mean value theorem, and its converse, are proved directly, using only the corresponding theorem of Gauss, and its converse, in potential theory.

From authors' summary

1633. Sheremet'ev, M. P., and Khlebinkov, D. G., Elastic equilibrium of a semiplane with a clamped edge (in Russian), *Dopovidi ta Povidoml. L'vovsk. In-ta* no. 7, part 3, 286–292, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12993.

The problem is investigated regarding the elastic equilibrium of an isotropic semiplane $y \leqslant 0$, the boundary of which is joined with an infinitely long thin elastic rod of constant rigidity, on which distributed transverse and longitudinal loads and a deflection moment are acting with intensivities of $q(x)$, $n(x)$, $m(x)$. One of the principal axes of inertia of each transverse section of the rod lies in the plane being observed. Let $f(x)$, $g(x)$ be the normal and tangential stresses on the contour of the weld. It is shown that $f(x)$ and $g(x)$ satisfy the following system of integro-differential equations

$$G_1 \alpha f'(x) + G_1 \frac{\beta}{\pi} \int_{-\infty}^{+\infty} \frac{g'(t)\,dt}{t-x} \, n(x)$$

$$G_2 \frac{\beta}{\pi} \int_{-\infty}^{+\infty} \frac{f'''(t)\,dt}{t-x} + f(x) - F_2 \alpha g''' (x) = \frac{dm}{dx} - q(x)$$

where α, β are some elastic constants of the semiplane, G_1 and G_2 are the rigidities of the rod under tension and deflection. By putting forward $q(x)$, $n(x)$, $m(x)$ as Fourier integrals authors obtain closed formulas for the solution of this system. The Fourier integrals representing the solution converge subject to the condition that $q(x)$, $n(x)$, $m(x)$ are capable of absolute integration, while $n(x)$ and $m(x)$, in addition, possess everywhere a delimited derivative capable of integration. N. A. Rostovsev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1634. Rukhadze, A. K., and Dolidze, D. N., Secondary effects in the problem of the deflection by a transverse force of a homogeneous prismatic bar (in Russian), *Trudi Gruz. Politekhn. In-ta* no. 4(52), 49–62, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13009.

The problem is solved by the method of the small parameter. The solution leads to the determination of the five functions of two variables, satisfied by two Laplace equations, one Poisson equation, two biharmonic equations with right-hand side parts and some

boundary conditions, ensuring the existence of these functions. The solution obtained of the problem under investigation satisfied all the conditions except the frontal ones. To satisfy these an addition has to be made to the solutions found [for] some linear Saint Venant problem neutralizing the superfluous stresses on the faces.

A. Ya. Gorgidze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1635. Golovin, A. Ya., Equilibrium of a heavy elastic semiplane with a nonrectilinear boundary (in Russian), *Nauchno-tekhn. Inform. Byul. Leningrad Politekh. In-ta* no. 8, 57–69, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11390.

A solution is given for the problem on the equilibrium of a heavy elastic semispace, weakened by a semicircular excision. An approximate method is proposed of compensating loads for the solution of the problems given in the title. Numerical examples are given for a trapezoidal excision in the heavy semiplane, which are compared with the adopted approximate method of negative loading.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1636. Payne, L. E., The elastic spindle under concentrated torques applied at the poles (in English), *J. Sci. Engng. Res., India* **1**, 1, 37–42, Jan. 1957.

Title problem is treated as Michell problem in bipolar coordinates. System of functions generated (Legendre) parallels similar development in toroidal coordinates [see W. Freiberger, "Uniform torsion of an incomplete tore," *Australian J. Sci. Res.* **2**, p. 354, 1949]. Author claims uniqueness of solution in spite of singularity at poles. Solution is extended to corresponding exterior problem.

E. F. Masur, USA

1637. Wundt, B. M., A unified interpretation of room-temperature strength of notched specimens as influenced by their size, ASME Metals Engng. Conf., Albany, N. Y., April–May 1959. Pap. 59-MET-9, 13 pp.

1638. Forsman, N. A., Approximate determination of stress concentrations in an extended elastic bar with a notch (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 73–81, Mar. 1958.

A straight bar of circular and of rectangular section provided with a hyperbolic notch is considered. The curvature radius of the notch bottom equals approximately the neck radius. Author solves the bar of circular section using the variation calculus method presented by S. Shapiro, taking only the first number of the series. Author presents the searched-for stress function $\psi(z)$ either in the form of a solution of a complicated differential equation of the fourth order, or in the form of an exponential function. In the latter case the corresponding coefficient is determined from the minimum potential energy condition. A numerical example is given and compared with Neuber's accurate solution.

In the case of the bar of rectangular section the author proceeds from the solution of a plate of finite thickness provided with a hole, elaborated by M. Sadowsky and E. Sternberg. The theoretical results have been verified experimentally on rubber models.

J. Valenta, Czechoslovakia

1639. Florence, A. L., and Goodier, J. N., Thermal stress at spherical cavities and circular holes in uniform heat flow, ASME Trans. **81**E (*J. Appl. Mech.*), 2, 293–294 (Brief Notes), June 1959

Localized thermal stress occurs when a uniform heat flow is disturbed by a cavity, and dimensional analysis shows that the maximum stress developed, under the simplest conditions of linear thermoelasticity, is $k \cdot E\alpha\tau a$, where E is Young's modulus, α the coefficient of expansion, τ the undisturbed uniform temperature gradient, a a representative linear dimension of the cavity, and k depends only on the shape and orientation of the cavity and on Poisson's ratio ν. The problem is of interest in connection with fatigue failure in thermal cycling. It is solvable for a variety of cavity shapes. In this note, results are given for the spherical cavity and the circular hole.

From authors' summary

1640. Williams, M. L., Some thermal stress design data for rocket grains, *ARS J.* **29**, 4, 260–267, Apr. 1959.

Paper presents preliminary elastic stress-concentration factors in internal burning star rocket propellant grains due to thermal stresses. Author considers the particular case of a steady-state temperature difference across the grain, or for a specified heat flux. Internal temperature is determined using a voltage analogy, so that the Biot-Muskhelishvili analogy can be employed to transform the thermal stress field into an equivalent temperature-independent edge dislocation problem. The appropriate displacements are then applied to a series of photoelastic specimens of slotted grains and the stress concentration factors experimentally evaluated. Actual stresses are determined by comparison with a thick-walled cylinder of the same web. Data is presented in design chart form.

Previous paper by author [*ARS J.* **27**, no. 6, June 1957; AMR **11** (1958), Rev. 417] presented similar design data due to pressure differences.

H. Faught, USA

1641. Preist, D. H., and Taicott, Ruth, Thermal stresses in ceramic cylinders used in vacuum tubes, *Bull. Amer. Ceram. Soc.* **38**, 3, 99–105, Mar. 1959.

This paper describes an investigation into the behavior of ceramic cylinders used in vacuum tubes when subjected to heat which is generated during normal tube operation. A theory of stresses in terms of axial temperature gradients and the mechanical properties of the material and cylinder geometry is developed for the particular case of cylinders with cooled ends and temperature distributions that are symmetrical about the axis. Experimental test results using a machine specially built for this purpose are given for a number of different materials and geometries; these results confirm the validity of the theory under certain conditions of practical importance. The effects of grinding and of firing on thermal stress resistance were studied, and a thermal stress resistance factor is tabulated for various materials.

From authors' summary

1642. Sutherland, R. D., and White, F. M., Jr., Thermal stresses in a square plate with a central circular hole subjected to an arbitrary temperature gradient, AFOSR TR 59–11 (Convair, Div. General Dynamics Corp., TM 349–2; ASTIA AD 209 850), 33 pp., Feb. 1959.

An analysis of the thermal stress problem in a thin square plate containing a single concentric circular perforation is presented for an arbitrary temperature distribution. The results of the analysis are applied to a plate subjected to a simple doubly-symmetrical temperature distribution. The hoop stresses are calculated around the perimeter of the perforation and are presented as functions of angular displacement for four different inside radii.

From authors' summary

1643. Piechocki, W., The stresses in an infinite wedge due to a heat source (in English), *Arch. Mech. Stos.* **11**, 1, 93–109, 1959.

A thin plate in the form of an infinite wedge with the apex angle $\leqslant \pi$ and free edges is subjected to the action of a point source of heat, located inside the region. The stress components are obtained using the potential of thermoelastic displacement and auxiliary Airy function. These functions are determined from a system of two homogeneous equations by dividing the region of the wedge into two parts by a line containing the point of application of the heat source. The solutions have the form of Fourier integrals and may be expressed in terms of elementary functions only for certain particular values of the apex angle of the wedge.

From author's summary

1644. Aga, M. S., Problem of the thermostaticity in some bodies of cylindrical symmetry (in Russian), *Sb. Nauchn. Trudi Leningrad Inzh.-stroit. In-ta* no. 26, 136–144, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13002.

An investigation is made of the unsteady distribution of the temperature in a plane sectorial region, bounded by two arcs of the periphery and by two sections of the radii. The solution is obtained by the Fourier method in the form of a series. The convergence of this series is not tested; special cases are studied, corresponding to different conditions of heat exchange across the boundary of the region. The thermoelastic displacements and stresses, corresponding to the investigated temperature regimes, were not examined. N. A. Kil'chevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1645. Aksel'rad, E. L., Calculation for shells, heterogeneous in their thermoelastic properties, and its application to bi-metallic elements in apparatus (in Russian), *Trudi Leningrad In-ta Aviats. Priborostroenie* no. 24, 41–96, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13027.

A calculation is given for bi-metallic elements in the form of a strip and for a shell of rotation, taking into account the thermal stresses. The first part of the paper brings together the general problem on the deformation of a shell with variable elastic constants with consideration for the temperature and the problem on the deformation of a homogeneous evenly-warmed shell which is under the action of a certain load. The second part is devoted to solutions of concrete problems on the determination of stresses and deformations in bi-metallic shells and plates. Experimental data are furnished which confirm the calculations.

E. F. Burmistrov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1646. Nemenman, M. Z., A graphical method for the determination of the stresses during the torsion of axially symmetrical shafts (in Russian), *Sb. Nauchno-tekh. Rabot. Azovo-Chernomorsk. In-ta Mekhaniz, S.-kh.* no. 10, 293–296, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11414.

The basic ideas contained in Willers' known work [*Z. Math. Phys.* **55,** 1907] are reproduced. Author apparently is unaware of the fact that an exposition in Russian of the above work is contained in a book by S. P. Timoshenko and Dzh. Lessel's ["Applied theory of elasticity," Moscow Gostekhizdat, 1932].

K. V. Solyanik-Krassa

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1647. Petrova, N. A., and Shashin, M. Ya., Initial data for the calculation of torsion shafts (in Russian), Questions relating to the design, manufacture and service of springs, Moscow-Leningrad, Mashgiz, 1956, 113–121; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11805.

The advantages are enumerated of torsion shafts as a means of effecting spring-cushioning, and the defects of existing methods of calculation are pointed out in regard to their stability when gaged by the characteristics emanating from tests for statical tension. A system of calculations for torsion shafts is proposed, the material being a high-duty alloy steel, the shafts being subjected to deflection and torsion. Based on the experimental data the relation is brought in of the dependence of the factor of declination of the line of boundaries of the delimited endurance on the diameter of the shaft and the relations of the characteristics of the fatigue and static strengths of the steel. V. A. Byikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Viscoelasticity

(See also Revs. 1709, 1758, 1759, 1814)

1648. Biot, M. A., Folding of a layered viscoelastic medium derived from an exact stability theory of a continuum under initial stress, *Quart. Appl. Math.* **17,** 2, 185–204, July 1959.

Stability is examined here in the sense of the rate of growth of a disturbance to an initial uniform flow of a continuum under uniaxial compressive stress. The disturbances considered are of one special type; the general question of bifurcation is not examined. The material is viscoelastic, defined through an integro-differential operator. The incremental strains are treated as infinitesimal, but in the field equations proper account is taken of the possibility of large rotations.

Two main problems in plane flow are solved: (1) a semi-infinite medium under compression parallel to its surface, which develops a sinusoidal waviness from a vanishingly small initial geometrical irregularity or through the sudden application of a steady disturbing normal loading; (2) a layer of one material embedded without friction in an infinite body of another, both under compression parallel to the layer, when the latter develops sinusoidal folds. In (1) numerical results are obtained for the limiting case of an elastic solid; as was to be expected, the pre-stress must be of the order of the rigidity modulus if the waviness is to be appreciable. In (2) when the layer thickness is small compared with the wavelength the results are compared in detail with author's previous treatment of this problem by a thin-plate-type of analysis. R. Hill, England

1649. Griest, A. J., Sabroff, A. M., and Frost, P. D., Effect of strain rate and temperature on the compressive flow stresses of three titanium alloys, *Trans. Amer. Soc. Metals* **51,** 935–944, 1959.

1650. Patel, S. A., and Venkatraman, B., Creep behaviour of columns, AFOSR TN 59–530 (Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech. Rep. 422; ASTIA AD 216 537), 84 pp., May 1959.

A survey of theoretical investigations of linear and nonlinear creep buckling of columns carried on at Brooklyn Polytechnic Institute during the past seven years. G. Gerard, USA

1651. Besseling, J. F., A theory of elastic, plastic, and creep deformations of an initially isotropic material showing anisotropic strain-hardening, creep recovery, and secondary creep, *J. Appl. Mech.* **25,** 4, 529–536, Dec. 1958.

On the basis of rather elementary thermodynamic concepts and the dubious assumption of a unique relation between the plastic or the quasiviscous dissipation potential and the elastic potential, stress-strain and creep-time relations for an inhomogeneous continuum are derived by adding the various potentials of a number of component volume-elements with different material parameters. Introducing arbitrary simple functions for the assumed relation between dissipation potentials and elastic potential it is shown that the trend of observed stress-strain and creep-relations can be fairly well reproduced.

A. M. Freudenthal, USA

1652. Poritsky, H., and Fend, F. A., Relief of thermal stresses through creep, *J. Appl. Mech.* **25,** 4, 589–597, Dec. 1958.

Under the (dubious) assumption that a family of observed creep curves can be considered as representing an "equation of state," the one-dimensional creep equation is generalized with the aid of the second invariants of the stress and strain deviations. Linearizing the problem over short-time intervals for which the creep rate and stresses are assumed constant the differential equation of the radial displacement of the infinite cylinder with parabolic

radial temperature distribution is established and solved for each time interval; the strain- and stress-components are then derived for the various intervals. A. M. Freudenthal, USA

1653. Rozovskii, M. I., On nonlinear integral equations of creep for a cylindrical concrete shell, subjected to external pressure (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 139–142, Sept. 1958.

For three-dimensional applications, author generalized his earlier equations of creep deformations. These are specialized for the case of thick-walled cylinders subjected to external pressure. For incompressible material, neglecting axial deformations, a method of successive approximations for solving the nonlinear equations is discussed. First approximations for radial and tangential stresses and strains are found.

E. P. Popov, USA

1654. Tzydzik, M. A., and Lukomskaya, A. I., Improvements in the method of determining the creep in rubbers when in tension at elevated temperatures (in Russian), *Trudi N. -i. In-ta Shin. Promsti* no. 4, 113–125, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11932.

A brief analysis is given of existing methods for testing rubbers and other high polymer materials for creep. An improved method for testing for creep is proposed; the test samples are ring-shaped, the material vulcanized rubber, the test is for tension at elevated temperatures. The apparatus and the test procedure used are described. The apparatus is characterized by the smooth nature of the loading of the samples, by the possibility of maintaining the constancy of the temperature, and in case of necessity, the constancy of the tension. A rheological model of the polymer is furnished and an equation derived describing the relation of the deformation to the time at constant tension. It is established that the indicators of the rubber's creep depend on the thickness of the test samples, the specific load and the test temperature. It is shown that, at room temperature, the creep is linked with retarded elastic deformation and appears to be reversible; at high temperatures, however, the creep coincides with the irreversible deformation and may serve as a measure of the ageing of the rubber. S. A. Ivanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1655. Malinin, N. N., Calculations for the strength and creep of the working blades and discs of turbomachines (in Russian), Avtoref. Diss. Dokt. Tekhn. Nauk, Mosk. Vyssh. Tekhn. Uchshche Im. Baumana. Moscow, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3277.

1656. Namestnikov, V. S., On creep for various load conditions in a complex state of stress (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 83–85, Oct. 1957.

This is the second paper published by the author on this subject. In the previous paper [AMR **12** (1959), Rev. 4346] he considered creep under constant load in a complex state of stresses and suggested an addition of a new factor, shear stress, to the generally accepted equation for the creep.

In the work reported in this paper, specimens (austenitic steel) are preloaded in tension, then the load is changed to torsion and vice versa. The creep curves presented clearly show that previous tension (torsion) has no substantial effect on consequent creep in torsion (tension). It is also shown that the proposed equation for creep in the previous part of this work does not hold for the described sequence of loading. Finally, author indicates that his experiments invalidate the theory of proportionality of the deviators of stress and strain expressed in the form $3\varepsilon/\sigma = \gamma/\tau$ W. D. Sylwestrowicz, USA

1657. Goldshtein, M. N., Creep and the prolonged durability of clay types (in Russian), Trudi Coveshchaniya po Inzh.-Geol. Svoistvam Gorn. Porod i Metodamikh. Izucheniya, Moscow, 1957, 5-15; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11633.

Known concepts are given on the creep, relaxation and long-term durability of materials. On the strength of experiments carried out by the author on different clays, in their disturbed and virgin states, to determine their prolonged durability when subjected to single and tri-axial compression, an empirical relation was established between the long-term durability and the length of time the samples were under test. Results are given for the tests for the determination of the long-term durability of an "illitovoi" clay with two values for the initial humidity. It was established that shedding the load and a period of rest influence the course of the process of deformation only in those cases when the rest took place before the disruption of the samples. It was also established that disruption took place regularly when the soil reached one and the same degree of relative deformation, for the given conditions for the test. On the basis of works devoted to the study of the internal forces acting on the clay, a subdivision of the character of the disruption of the bonds is advanced and also a simplified rheological model devised by the author of the elastic-plastic-viscous relaxing body. Basing the hypothesis on the circumstance that disruption takes place when the soil samples attain one and the same degree of relative deformation, a method is proposed for the determination of long-term durability of soils by tests on one sample by tri-axial compression. It appears that for definite confirmation of the method put forward, and in order to establish the limits of its application, further investigations are required. S. R. Meschyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1658. Rudee, M. L., The effect of irradiation on creep, *J. Amer. Soc. Naval Engrs.* **71**, 3, 453–456, Aug. 1959.

1659. Akhmerov, A. F., The theory of processes of cold bending of components (in Russian), *Trudi Kazansk. Aviats. In-ta* no. 36, 35–48, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11532.

The elastic-plastic bending of rods, the material of which possesses the property of toughening, is investigated. The curve of the deformation in the plastic region can be expressed approximately by the stepped relation $\sigma = A\varepsilon^n$ (*). For sections of rectangular type, double-I, channel, etc., (that is, sections whose plane of symmetry coincides with the neutral plane) the relationship is obtained between the deflection moment and the curvature. It is shown that where the radius of the curvature of a section is $\rho < 1/3\rho_T$ (where ρ_T is the radius of the curvature corresponding to the appearance of plastic deformation) the calculation of the magnitude of the deflection moment can be carried out on the assumption that the curve of deformation along its whole extent (that is in both the elastic and plastic regions) will be approximately satisfied by expression (*). Relations are introduced for the calculation of the radius of the curvature at which, in the process of unloading plastic, deformation appears in the bar. When deducing this relation, Bauschinger's effect is taken into account as was done by V. V. Moskvitin [*Vestn. Mosk. Un-ta* no. 8, 1951]. Yu. A. Rakovshchik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Plasticity

(See also Revs. 1628, 1653, 1655, 1672, 1725, 1729, 1937)

Book—1660. Prager, W., An introduction to plasticity, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1959, viii + 148 pp. $9.50.

The goals of this book are concisely stated in its preface: "It is hoped that the book will usefully supplement the traditional texts on strength of materials and theory of structures which are primarily concerned with elastic behavior. The restriction to selected topics from the theory of perfectly plastic solids made it possible to lead the reader to the front of present research without presupposing prior familiarity with the subject." The author achieves these goals with his customary skill.

The contents of the book are divided into four chapters: Mechanical behavior of plastic solids, Mechanical behavior of plastic structures, Limit analysis and design, and Finite plastic deformations. Since the contents of the original German edition are discussed in detail in its review [AMR **9** (1956), Rev. 1094], only revisions and additions are mentioned here.

Primary expansion is in Chapter 3, where the following additions may be found: illustrative examples on the principles of virtual velocities and limit analysis; new section on uniqueness of solutions; additional examples of limit analysis of plates; determination of displacements in beams and frames; reversed loading of plates; new section on limit design of frames and sandwich plates. Parts of Chapter 4 have been rewritten for greater clarity, a discussion of discontinuities is included, and additional examples of extrusion and compression of a slab have been inserted.

About 70 new publications have been referred to, some 50 of them in Chap. 3 (note that one reference number may cover several publications). The value of the present edition is further enhanced by the inclusion of several problems at the end of each chapter.

It is indeed a pleasure to see this valuable work brought up to date and made available to an English-speaking audience.

P. G. Hodge, Jr., USA

1661. Budiansky, B., A reassessment of deformation theories of plasticity, *ASME Trans.* **81**E (*J. Appl. Mech.*), 2, 259–264, June 1959.

The so-called deformation, or finite, theories of plasticity, which relate total plastic strain to final stress, are applicable to proportional loading, but they do not have general validity for all stress histories. These two characteristics seem to have led to the widespread but unjustified belief that the predictions of a deformation theory are physically unsound for any stress history except proportional loading. Author shows that deformation theories of plasticity may be used for a range of loading paths other than proportional loading without violation of general requirements for the physical soundness of a plasticity theory. The extent to which deviations from proportional loading are admissible on this basis is calculated quantitatively for the simple deformation theory of Nadai. It is shown that the lower the strain-hardening rate of the uniaxial stress-strain curve, the greater are the permissible deviations from proportional loading.

F. Chmelka, Austria

1662. Shevchenko, K. N., On the methods of solving certain elasto-plastic problems (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 152–155, Sept. 1958.

In several previous papers author solved elastic-plastic problem of half-plane loaded with concentrated normal force. Assumption of linear plastic hardening led to discontinuous displacements on the elastic-plastic boundary. In the reviewed paper author shows that this discontinuity is connected with discontinuity of slope on stress-strain diagram. The problem was solved once more for a stress-strain relation continuous with first derivative, namely with a parabolic connecting curve. Using Hencky-Ilyushin theory of plastic deformation author found no discontinuity in displacements.

M. Zyczkowski, Poland

1663. Chernina, V. S., The carrying capacity of a circular ring plate subjected to uniform pressure (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 33–39, July 1958.

Author considers a circular ring plate of an ideally plastic material either supported or built-in on both edges. The plasticity condition is taken in the form of a hexagon. Both the upper and the lower limits of the carrying capacity are determined, the lower limit being determined from the equilibrium condition, edge conditions and from the given plasticity condition. Author determines the upper limit of the carrying capacity on the basis of a properly chosen strain velocity of the middle ring plate area complying with the corresponding edge deformation conditions. If both these limits agree, author takes the value of the carrying capacity thus determined to be accurate.

J. Valenta, Czechoslovakia

1664. Ke-Chzhi, K., On work-hardening of plastic solids, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22,** 4, 758–762, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

A law of work-hardening plastic solids has been proposed by Prager [*J. Appl. Mech.* **23,** no. 4, 1956]. When applied to two-dimensional state of stress, this law contradicts the assumption of original isotropy. By establishing such a law as a special case of a generalized Tresca condition for three-dimensional state of stress the contradiction may be essentially removed.

E. P. Popov, USA

1665. Prager, W., Non-isothermal plastic deformation (in English), *Proc. K. Ned. Akad. Wet.* (*B*) **61,** 3, 176–182, 1958.

Paper presents a theory of nonisothermal deformation of rigid, work-hardening solids. The proposed constitutive law contains an unspecified function of temperature, stress, strain and strain history, thus leaving ample room for the incorporation of empirical evidence. A typical boundary-value problem is formulated, and the uniqueness of its solution is discussed.

H. Faught, USA

1666. Stevens, L. K., Control of collapse mechanisms in triangulated frames, *Austral. J. Appl. Sci.* **10,** 2, 138–155, June 1959.

Paper is devoted to the limit analysis of continuous beams and frames whose elements are trusses. If the slenderness ratio of the compressed members of these trusses have intermediate values (say, between 30 and 100), which is the usual case, their deflection-force diagram plunges abruptly downward and yields a lack of rotation capacity of the truss, which prohibits the use of conventional plastic analysis to triangulated beams or frames.

On another side, the mode of collapse of these frames can be controlled by strengthening the critical compression members and eventually subjectting them to prestressing.

The paper discusses all these possibilities and gives a fully solved numerical example.

C. E. Massonnet, Belgium

Rods, Beams and Strings

(See also Revs. 1636, 1638, 1660, 1700, 1703, 1710, 1715, 1719)

Book—1667. Englisch, C., Piston rings, Vol. I: Theory, manufacture and design [Kolbenringe. Vol. I: Theorie, Herstellung und Bemessung], Berlin, Springer-Verlag, 1958, vii + 457 pp. $18.55.

This book contains the most extensive coverage on the subject of piston ring presently available. The author's aim is to write a piston ring encyclopedia. His work will consist of two volumes. Theory, manufacture and measuring is treated in the first volume. The second volume will be available in the foreseeable future and will describe piston ring behavior in the field and in testing. This

logical division has some shortcomings because ring wear, one of the basic considerations for ring design, is being discussed in the second part. The theory of the elastic ring is well covered and organized. All works of interest in this field until 1957 are surveyed.

The same can be said about Chapter III—Ring sealing, and Chapter IV—Friction. Approximately two-thirds of the book is filled with extensive descriptions of rings of various materials and of the numerous ways to manufacture them. Also included are very laborious descriptions of the processes, tools and machines utilized in ring manufacture.

It is felt that the author has difficulty with the limitation of the scope of the book. The descriptive metallurgical part appears more extensive than other parts. Besides, it seems that this part is written for a reader of a different educational level than the theoretical part. In the metallurgical section, some concepts are explained which have been used without explanation in previous chapters (i.e., Modulus E). Despite these finite shortcomings, the book is very useful for anyone who desires a clear and possible broad coverage of piston problems. A. L. Nasvytis, USA

1668. Solov'ev, Iu. I., The action of a concentrated force on an eccentric ring, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22,** 5, 989–996, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Expressions are given for the stress function and for the stress components which result from the action of an arbitrary concentrated force on the outer boundary of a circular ring with an eccentric circular hole. The forces which equilibrate the given concentrated load are assumed to be distributed along both boundaries and vanish identically if the applied loads are self-equilibrating. Results are stated in the form of rapidly convergent Fourier series; the singularities which arise due to the presence of concentrated forces are taken care of explicitly. F. V. Pohle, USA

1669. Marpachev, N. F., Investigation of (lamellar) torsion in a laminated shaft (in Russian), Collection of papers; Chelyab. Politekhn. In-ta no. 11, 20–47, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11806.

The calculations are investigated for a torsion shaft consisting of thin sheets bundled together. The rigidity of the shaft when in torsion is determined by the energy method. When evaluating the components of energy the author used a model in which each sheet can be subjected to torsion and deflection. The tension on the sheets is disregarded. As a further step in the calculation a correction factor is introduced to take into account the friction between the sheets. The comparison carried out between the calculated and experimental results shows good convergence.

V. I. Feodosiev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1670. Bychkov, P. G., The carrying capacity of rods of non-round sections in pure and constricted torsion with plastic deformations (in Russian), *Trudi Mosk. Torf. In-ta* no. 5, 257–274, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11503.

An approximate evaluation is given of the behavior of bars of rectangular and double-I sections during pure and constricted torsion in the presence of plastic deformations. It is deduced that, in torsion in a constricted section of the bar, plastic deformation extends over the whole section later than in an unconstricted section. The results of a large number of experiments are given for the determination of the carrying capacity of steel bars at different external loadings, including the case of application of the forces in the forward and backward directions. Broadly speaking the experimental results agree basically with the results of the calculations carried out by the author's method.

V. V. Moskvitin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1671. Zhichkovskii, M., Determination of the critical forces for nonprismatic elastic bars by the method of partial interpolation (in Russian), *Byul. Pol'skoi Akad. Nauk, Otd.* (4), **4,** 4, 233–245, 1956; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11687.

A numerical determination is furnished for the critical forces acting on an ideally elastic bar of varying section, supported at the ends or clamped at one end. It is assumed that the dimensions of the section vary linearly with length, while the section's moment of inertia varies in accordance with the principle $I(x) = I_0 \left[1 - (1 - K)\frac{x}{l}\right]^n$ $(n = 1, 3, 4)$, where k is some constant magnitude; l is the length of the bar. Author has produced 6-figure tables of the coefficients of stability analogous to the 3-figure existing tables compiled by A. N. Dinnik ["Longitudinal deflection." Moscow, Izd-vo Akad. Nauk SSSR, 1955]. A method for interpolation is proposed, convenient for use in the solution of transcendental equations obtained while determining the critical loads.

I. E. Shashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1672. Shneiderovich, R. M., Elasto-plastic bending of beams and systems of beams (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 130–134, Mar. 1958.

Assuming that Poisson's ratio is 1/2 and the "modulus of elasticity" is a variable depending on strain, author discusses combined bending and stretching of statically determinate and indeterminate beams and frames.

Functions of plasticity relating the forces and deformations in a cross section are introduced. By means of these functions the equations of elasto-plastic bending are presented as generalizations of the equations of elastic bending, and the methods developed for elastic bending may be used to solve problems of elasto-plastic bending (with the aid of successive approximations). Analysis of a chain link is given as an example.

R. Schmidt, USA

1673. Krasnosel'skii, M. A., The examination of the spectrum of the nonlinear operator in the vicinity of the point of bifurcation and the application to the problem of the longitudinal deflection of a compressed bar (in Russian), *Uspekhi Mat. Nauk* **12,** 1, 203–208, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11708.

1674. Vol'vich, S. I., and Zotov, B. E., Calculations for continuous beams by a new method (in Russian), *Sb. Naucbn. Soobsbch. Saratovsk. Avtomob.-Dor. In-ta* no. 7, 53–56, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5900.

1675. Minkhorst, J. H. K., The straight beam with elastic supports at equal intervals (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 86–95.

Paper considers a uniform beam of infinite length on equally spaced, identical elastic supports, loaded in one span. The "five-moment" equation relating bending moments at five consecutive supports is then solved analytically by the usual techniques of solving difference equations. B. Budiansky, USA

1676. Tuma, J. J., Analysis of continuous beams by carry-over moments, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST5 (*J. Struct. Div.*) Part I, Pap. 1762, 32 pp., Sept. 1958.

Author develops a relaxation method for studying continuous beams in the general case of transverse loads, applied couples, displacement of supports and change in volume. The case of a variable depth beam is also discussed.

The method differs from other iteration procedures by the relaxation technique which (1) admits at each support a starting moment and then obtains a final moment, and (2) uses carry-over factors.

The equation which gives the moment on a support j is

$$M_j = r_{ij}M_i + m_j + r_{kj}M_k$$

where m_j is the starting moment, r_{ij} and r_{kj} are the carry-over factors and M_i and M_k are the redundant moments.

The tabular method for using this equation is developed and examples of its application to reinforced-concrete beams are given.

G. B. Buzdugan, Roumania

Plates, Shells and Membranes

(See also Revs. 1593, 1645, 1660, 1663, 1668, 1704, 1705, 1706, 1708, 1788, 1803, 1808, 2054)

1677. Bassali, W. A., Stresses due to a free circular hole in an infinite thin isotropic plate under certain normal loadings, *Bull. Calcutta Math. Soc.* **50,** 3, 107–122, Sept. 1958.

Paper deals with the problem of an infinite plate with an outer free edge and an inner free circular boundary, when the plate is supported at any number of interior points and normally loaded over a circular patch with a load symmetrical to the center of the patch, and given by $p = p_0 R^n(\cos\phi - \alpha)$, where $n > 0$, α is a constant angle and the origin of coordinates is at the center of the patch. This type of loading is of interest because it includes, as a particular case, uniformly varying pressure $p = p_0 R\cos(\phi - \alpha)$, and can be made to tend to a couple nucleus at center of patch as its radius tends to zero, the axis of the couple being in the plane of the plate. A solution in finite form is thus obtained for an infinite plate with an outer free boundary and containing a free circular hole, the plate being acted upon by any normal system of external isolated forces or couples or both at the same time. Using complex variable the method of derivation is comparatively simple and the form of theory is greatly simplified by using complex combinations of stress components. The solutions are exact within the limitations of small-deflection plate theory.

From author's summary by E. Fliess, Argentina

1678. Choudhury, P., Stresses due to a certain type of nucleus of strain in an infinite slab of transversely isotropic material (in English), *Riv. Mat., Parma* **8,** 4/5, 337–343, 1957.

Considered infinite slab has one face free and the other rigidly fixed. Origin of coordinates is taken on the free boundary and axis of elastic symmetry is z-axis, drawn into the body at right angles to this plane. The displacements are expressed by a function of coordinates Φ, taking third component as zero, and thus a partial differential equation of Φ in terms of coordinates x and y is obtained. Nucleus of strain in particular problem proposed in paper is defined as a constant divided by a certain expression in terms of x, y, and z. A stress system is imposed to satisfy the boundary conditions of zero stresses at free plane face and zero displacements at rigidly fixed face. Thus reduced partial differential equation was solved and, using Hankel inversion formula, two constants were found. Hence the stress distribution is given by the total sum of stresses due to the nucleus of strain and that due to the superimposed system. An example of the proposed method for problems of same kind in hexagonal crystals such as beryl is given, with results in tabulated form.

B. O. Kuzmanovic, Africa

1679. Csonka, P., Application of the theory of orthotropic plates to obtain results of loading tests on reinforced concrete rib slabs (in German), *Bautechnik* **35,** 11, 436–439, Nov. 1958.

When testing a slab with closely spaced ribs ordinarily only a part of its area is loaded and only deflection of one rib is measured. Therefore load distribution on the different ribs is unknown and evaluation of test becomes difficult. Present investigation is to find this distribution by substituting construction by an orthotropic plate.

Considered case concerns an infinite strip between two parallel supports with ribs orthogonal to them. Load is distributed uniformly in a rectangle. Since loading may be built up of an elementary load with a known solution by a Fourier series development in rib direction and integral calculus in direction perpendicular to it, partial loads are simple to assign. Result agrees very well with earlier result obtained more simply by the author [*Bautechnik* **35,** 10, 396–399, Oct. 1958].

W. Mudrak, Austria

1680. Burmistrov, E. F., Stress concentration in a plate with an opening (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 41–47, Aug. 1958.

Using Muskhelishvili's method, the solution of two-dimensional problem for isotropic indefinitely extended plate with a hole of the general form is obtained. The problem is reduced to solving the system of algebraic equations and is the generalization of known special problems.

Z. Olesiak, Poland

1681. Silberstein, J. P. O., The infinitely wide cantilever plate under concentrated load, Aero. Res. Lab. Melbourne, Austral., Rep. SM 257, 32 pp., May 1958.

A solution by the Fourier transform method for a lateral load is given. By distributing the load over a small area in such a way as to keep the bearing stress within reasonable limits, physically significant bending stresses are found for all points of the plate. In the course of solution a Γ function-type integral is evaluated. This may be of interest in itself.

Former work on the subject is not mentioned in the paper. Author seems not to have known of the solutions of the problem given by C. W. MacGregor [*Mech. Engng.* **57,** p. 225, 1935] and T. J. Jaramillo [AMR **4** (1951), Rev. 1507] nor the papers of W. T. Koiter and J. B. Alblas [AMR **8** (1955), Revs. 611, 612 and 3365].

E. Monch, Germany

1682. Galletly, G. D., Optimum design of thin circular plates on an elastic foundation, Instn. Mechn. Engrs., Prepr., 12 pp., 1958.

An analysis is given of a thin, constant-thickness, circular plate subjected to uniform lateral pressure. The plate is assumed to rest on a uniform elastic foundation and to be elastically restrained at the edges against rotation and vertical deflection. Curves are presented for the location and the magnitude of the maximum stress in the plate as functions of two nondimensional parameters. From these curves, the optimum value of edge elastic restraint can be easily determined.

One interesting result of the analysis is that it is possible to design plates in which the maximum stress is between 25 and 50% smaller than that in similar plates with simply supported ends. This possibility does not appear to have been appreciated before and its utilization has obvious economic advantages. Another result of interest is that the value of the dimensionless elastic rotational restraint parameter giving minimum thickness is almost a constant for most cases occurring in practice.

From author's summary by J. M. Hedgepeth, USA

1683. Sherman, D. I., Elastic equilibrium of a plate supported along the edge (in Russian), *Izv. Akad. Nauk ArmSSR, Ser. Fiz.-Matem. Nauk* **10,** 3, 35–46, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13032.

The problem is solved of the elastic equilibrium of a thin plate, hinge-supported along the edge, the center plane of which occupies a single bond region. The solution is merged with a system of two Fredholm integral equations, the nuclei of which are continuous functions of the arc abscissa. The uniqueness of the solution of the obtained system of integral equations is substantiated. The effectiveness of the given solution is noted in comparison with solutions of the analogous problem obtained previously by other authors.

M. P. Sheremet'ev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1684. Varvak, P. M., and Guberman, I. O., Deflection of a square plate with different conditions on the edges (in Russian), *Inform. Materialy. In-ta Stroit Mekhan., Akad. Nauk USSR* no. 10, 3-56, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11449.

The paper is closely allied in content with P. M. Varvak's book ["Development and application of the method of networks for the calculations of plates," Part 2. Izd-vo Akad. Nauk USSR, 1952]. A square plate is investigated with nine variants of its boundary conditions: (1-2) all the sides are free, three or four angles of the plate are supported; (3-8) one side, two intermediate sides or two independent sides are free, the rest are either freely supported or clamped; (9) two independent sides are free, the third is freely supported, the fourth is clamped. Typical differences equations are derived for the deflections of internal points, points on the contour or next to them. Deflections at points beyond the contour are excluded from consideration on the basis of the boundary conditions. At a spacing for the network of a quarter of a side of the plate for each of the given nine variants with two values for Poisson's coefficient (1/6 and 3/10), there were obtained: (a) the matrices of the coefficients of the difference equations; (b) the matrices of the numbers of influence of the free terms. The applications of matrices (b) are illustrated by examples of calulations for plates with a continuous and a concentrated load. The latter is considered to be distributed over the area of the square, the side of which is equal to the space in the network, while for the case of a load on a free edge, along the plane of the adjoining half-square. It is indicated that the results can be used also for the calculations for rectangular plates, superimposed on a square network.

Ya. B. L'vin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1685. Pinskii, M. G., Bending of a plate resting on elastic double-I beams during heating (in Russian), *Izv. Tomskogo Politekhn. In-ta* **85,** 333-342, 1957; *Ref. Mekh.* no. 10, 1958, Rev. 11451.

The bending is investigated of an evenly loaded rectangular plate, two opposite edges of which are fully supported, while two others are supported on elastic double-I beams, when the distance e from the axis of the beam to the central surface of the plate may vary from a zero value to a value of e_{max}; in the latter case the plate would be found lying on the top of the double-I beams. In the solution of the problem the deflection-torsion deformation of the beams is disregarded. Graphs were obtained for the different correlations of the beams and the plate, showing the change of the deflection moments of the bending in relation to the parameter $\alpha = l/b$, where l and b are the lengths of the sides of the plate. For the particular case $\alpha = 1$ the results obtained agreed well with the results of B. G. Galerkin [Collection of works, Vol. 2. Moscow, Izd-vo Akad. Nauk SSSR, 1953] and S. P. Timoshenko ["Theory of elasticity," Moscow, Gostekhizdat, 1934]. The graphs show that the most unfavorable cases of disposition of the plate relative to the beams will be found with $e = 0$, that is when the axis of the beam coincides with the central surface of the plate. An analysis of the curves also shows that, in order to increase the stability of the plate being supported on the double-I beams, it is sufficient to take the correlation of stiffness as $\lambda = EJ/bD = 4$, at which the effect of the beams' deflection on the deformation and the plate's stresses is represented by only 10-15% in all. The heating of the plate is also examined. It is assumed that the changes of temperature with the thickness of the plate proceed in accordance with the linear principle and that when $\lambda = 4$ the plate supported on the elastic beams can be investigated as a plate hinge-supported over the whole contour.

B. N. Lopovok
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1686. Morley, L. S. D., The approximate solution of plate problems (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6,** 22-30.

Author implies that his method is similar to those of Weinstein, and Diaz and Greenberg in biharmonic problems, but that, in contrast, his development rests on energy consideration. By first subtracting out a particular solution (that does not satisfy boundary conditions), the problem of finding the displacements of a laterally loaded plate of arbitrary shape is reduced to determining a biharmonic function satisfying certain known boundary conditions. Author assumes approximate solution to this reduced problem as a series of biharmonic functions. The boundary conditions are then enforced (in a mean sense) by the imposition of a set of boundary integral conditions, each of which has the physical significance of a virtual work associated with shears and moments derived from one of the biharmonic functions. Several numerical examples are presented to confirm the accuracy and feasibility of the procedure.

B. Budiansky, USA

1687. Pohle, F., and Shaw, F. S., Stresses in an accelerated cylinder bolted to an elastic foundation (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **7,** 375-387.

Analytical solution is given for elastic cylinder subjected to inertia loading due to rapid acceleration perpendicular to axis of cylinder. Cylinder is bolted loosely at one end to elastic foundation whose spring constants differ in tension and in compression, and is free at the other end. Governing differential equations are those of Donnell.

From authors' summary by J. N. Goodier, USA

1688. Soare, M., On the determination of membrane stresses in thin shells of revolution (in Roumanian), *Studii Si Cercetari Mecan. Appl.* **10,** 2, 521-538, 1959.

Paper discusses the possibility of integrating the equilibrium differential equations with the aid of trigonometric series. Explicit expressions of the first harmonic are obtained for shells symmetrically loaded with respect to the revolution axis. Their deduction is based on the cantilever analogy, thus generalizing a previous remark made by Dischinger.

Stress expressions for several interesting cases are given in the appendix.

P. P. Teodorescu, Roumania

1689. Pagano M., and Greco, C., On the calculation of translation shells (in Italian), *G. Gen. Civ.* **96,** 12, 817-827, Dec. 1958.

An analytical approach is presented to the calculation of translation shells with circular directrices and rectangular plan, only shells without bending (membranes) being concerned. Computations are made by finite differences method, using a grid analysis. A shearing stress function is introduced, giving results with such a convergence that only first terms in summations must be considered for practical purposes. Real capacity of shells to bear normal stresses is taken in account as conditions at boundary. Edge prestressing can also be considered. A numerical example is given and its results checked by model tests, comparison showing accuracy of method is enough for technical design.

F. Correia de Araujo, Portugal

1690. Chattarji, P. P., On the stresses in twisted composite paraboloids, *Bull. Calcutta Math. Soc.* **50,** 3, 155-158, Sept. 1958.

Paper deals with the problem of a composite elastic paraboloid of two different isotropic materials twisted about its axis of revolution by a distribution of shearing stresses on one curved surface, the other curved surface being fixed to a rigid base. It is a strong solution by means of Bessel functions.

L. Foppl, Germany

1691. Kurshin, L. M., Equations of three-layered cylindrical shells (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 142–144, Mar. 1958.

Author presents six nonlinear equations with the six displacement components of the middle surfaces of the face layers as dependent variables.

Each layer is treated as an orthotropic shell. It is assumed that $E_{11} = E_{22} = G_{12} = 0$ for the core, and $E_{33} = G_{13} = G_{23} = \infty$ for the thin face layers. Here E, G are moduli of elasticity and rigidity. Indices 1, 2, 3 pertain to the directions of the generatrix, circular arc, and normal. The transverse deformations of the core and bending rigidity of the faces are not neglected; however, several additional simplifications common in the shell theory are introduced.

Comparisons are made with several existing systems of equations for sandwich plates and shells. The buckling problem is also formulated.

R. Schmidt, USA

1692. Loginova, M. A., Some problems dealing with large deformations in cylindrical shells (in Russian), *Vestn. Mosk. In-ta, Ser. Matem. Mekhan., Astronom., Fiz., Khimii* no. 4, 29–40, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13016.

A study is made of the momentless stressed state of a cylindrical shell, caused by the embedding of a peg of cylindrical form. The boundary derivatives of the shell are taken to be clamped to prevent displacements along the guide, while the conditions on the faces are assumed to ensure the homogeneity of the axial deformations. It is assumed that both the shell and the peg have planes of symmetry in which the vector of the force of reaction on the peg is situated. The material of the shell is taken to be incompressible; the hypothesis of the similarity of the deviators of the real stresses and the logarithmic elongation of the change of form are assumed to be operating. The relation of the intensity of the stresses to the intensity of the deformations is represented by a stepped function. The end relations are obtained, enabling the bond between the force of reaction on the peg and the magnitude of the penetration of the peg to be established, taking into account the effect of the mechanical characteristics of the material of the constructed shell and its geometry. Here consideration is also given to the effect of Coulomb friction and the direction of the tangential and guiding shell. The correlations obtained are simplified in the case of a plane deformation or a plane stressed state in the direction of the cylinder's axis.

L. A. Tolokonnikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1693. Ryayamet, R. K., Equilibrium of thin-walled elastic conical shells in the post-critical stage (in Russian), *Trudi Tallinsk. Politekhn. In-ta* **A**, no. 82, 104–115, 1956; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13015.

Investigations are made of the general stability of round conical shells including the apexes and fastenings along the bases, under the action of an evenly distributed external pressure. It is accepted that the configuration of the curved surface changes little by comparison with the moment of bifurcation of forms of equal weight. It is assumed that the magnitudes of the functions of stresses in the mean surface and the functions of deflection do not change appreciably during differentiation by the variable $x = s/s_0$ (the coordinate s is laid off along the generatrix from the vertex, s_0 is the full length by the generatrix and at the same time increases by $\varepsilon^{-0.5}$ times when differentiated by the angle of length θ); here

$$\varepsilon^2 = \frac{tg\beta}{\sqrt{12(1-\nu^2)}}\frac{T}{s_0}$$

t is the thickness of the shell, β half the angle of opening of the cone, ν Poisson's coefficient. Taking these assumptions into consideration the basic differential equations of the problem can be presented in a simplified form as

$$\psi'' \sin^2\beta + \frac{\varepsilon^2}{x^3\sin^2\beta}\varphi'''' + \varepsilon\left(\frac{1}{x}\psi''\psi'' - \frac{1}{x}\psi'\psi''' + \frac{2}{x^2}\psi'\psi' - \frac{1}{x^3}\psi\psi'\right) = 0 \quad [1]$$

$$\varphi'' \sin^2\beta - \frac{\varepsilon^2}{x^3\sin^2\beta}\psi'''' - \varepsilon\sigma\psi'' + \varepsilon\left[\frac{1}{x}\psi''\varphi'' - \frac{2}{x}\left(\psi''' - \frac{1}{x}\psi'\right)\left(\varphi'' - \frac{1}{x}\varphi'\right) + \frac{1}{x}\psi'\varphi'''\right] = 0 \quad [2]$$

Here ψ and φ are parameters corresponding respectively to the function of deflection and the function of stresses in the mean surface, σ is the parameter of the external load; the lines indicate derivatives by x while the dots by 0. The deflection function is approximately expressed in the form

$$\psi(x, \theta) = \psi_0(x) + \psi_1(x)\cos k\theta; \quad \psi_1(x) = x^2(1-x^2)a_r x^r$$

the coefficient k being the same as the one accepted in the solution of the linear problem regarding the stability of a shell "in the small"; $r = 2, 3, 4, 5$. Further on function φ is determined from the equation of joint deformation [1]. The equation of equilibrium [2] is integrated approximately by the Bubnov-Galerkin method. The change in the full energy of the system is calculated in comparison with the energy corresponding to the given level of external pressure. The smallest value for the energy is obtained with $r = 4$. Other variants of the expression for $\psi_1(x)$ are also examined. It was established that the non-axially symmetrical states of the shell may occur at pressures smaller than the upper critical. The load at which the energy of the system after the deflection of the shell is equal to the energy in the original state is approximately 93% of the upper critical value. It would have been desirable to continue the computations and to determine the magnitude of the lower critical pressure.

A. S. Bol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1694. Rekach, V. G., Calculations for slanting screwshaped (helical) shells (in Russian), *Sb. Trudi Mosk. Inzh.-stroit. In-ta* no. 27, 113–132, 1957; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13018.

A solution is found for a system consisting of two homogeneous differential equations for slanting shells in curvilinear coordinates, with the aid of trigonometrical series for the case of a straight helicoid and with the further aid of stepped series for an inclined helicoid. Directions are given for finding special solutions for a system of equations with a right-hand side part.

N. A. Alfutov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1695. Volkova, E. M., Calculations for a group of working blades for their deflection at various loadings on the blades (in Russian), *Trudi Leningrad Metallich. Z-da* no. 5, 231–239, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11813.

A theory is developed for the calculations of a block of working turbine blades of variable sections for their static deflection while taking into account the end number of blades in the block (first worked out by A. V. Levin, "Working blades and discs of steam turbines," Gosenergoizdat, 1953, 219–229) to meet the case when, when the steam inlet is partially opened, not all the blades are equally loaded. The problem merges with the solution of a heterogenous system of three equations relative to the moments M'_m and M''_m, being transmitted by wires to the m^{th} blade on its left- and right-hand side respectively, and to Q_m, the transverse force, acting in the plane of the disk on the m^{th} blade at the point of junc-

ture of the wire. The solution of the homogenous system corresponding to the heterogenous coincides with the solution derived earlier. The particular solutions of the heterogenous system are found in the form of polynomials

$$M''_m = A_0 + A_1 m + \ldots + A_{n-1} m^{n-1}$$

$$M'_m = B_0 + B_1 m + \ldots + B_{n-1} m^{n-1}$$

$$Q_m l = D_0 + D_1 m + \ldots + D_{n-1} m^{n-1}$$

where l is the length of the blade, n the number of blades in the block. Recurrent formulas are derived for the coefficients A_k, B_k, D_k $(k = 0, 1, \ldots, n-1)$, and in so doing the intensity of the load q_m acting in the m^{th} blade is approximately expressed in the form of a Lagrange interpolational polynomial

$$q_m = q_1 \frac{(m-2)(m-3)\ldots(m-n)}{(1-2)(1-3)\ldots(1-n)} + q_2 \frac{(m-1)(m-3)\ldots(m-n)}{(2-1)(2-3)\ldots(2-n)} + \ldots + q_n \frac{(m-1)(m-2)\ldots(m-n+1)}{(n-1)(n-2)\ldots 1}$$

where $q_j (j = 1, 2, \ldots, n)$ is the intensity of loading of the j^{th} blade. An example of the calculations is furnished for the statical deflection due to the pressure of steam on a block of blades of constant section, joined by a wire, for various cases of loading of individual blades in the block. A. D. Kovalenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1696. Mikeladze, M. Sh., The minimum weight of anisotropic shells (in Russian), *Soobshch. Akad. Nauk GruzSSR* **19**, 1, 11–18, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11504.

A sandwich model of the shell is investigated: the outermost layers with a thickness of Δ appear to be carrying surfaces, while the inner with a thickness of H appears to be a filler and takes on the intersecting forces, when $H \gg \Delta$. Basing his case on the Mizes-Hill conditions of flow (yield), utilizing the principle of the plastic potential and assuming that the plastic flow includes the full thickness of the shell, the author, in an earlier publication [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 85–94, 1957] obtained the relation $D = D = 4\Delta\lambda$ [1], where D is the velocity of dissipation, referred to the unit of area of the mean surface of the shell, λ is a constant by thickness of the nonnegative scalar multiplier. Assuming that the shell of minimum weight suddenly and wholly passes over to the state of flow, author takes $\lambda = \text{const}$, and then there follows from [1] the condition that $D/\Delta = \text{const}$ [2], the constancy of the velocity of dissipation on the unit volume of the carrying volume. It should be noted that in its application to the problem of the axially symmetrical deflection of a round isotropic plate the above condition, arising from quite other concepts, was obtained by Frieberger and Tekinalp *J. Mech. Phys. Solids* **4**, 4, 294–299, 1956]. The system of equations which solves the problem not only for shells but also for plates is recorded. Some ideas are put forward regarding the possibility of extending the conditions of type [2] to include the case of a monolayer shell.

In concluding the paper, "the problem on the optimum heterogeneity of the material" is put forward, i.e., in what way is it essential to put the principle of the change in the limits of flow of the material in relation to the coordinates to ensure that all points of the body instantaneously pass over to the flow state? As an example the solution of the problem is given for the optimal heterogeneity of a cylindrical tube and a spherical vessel, which are being subjected to the action of even internal pressure. Three unknowns, the radial and tangential stresses and the limit of flow, are determined by means of three equations (the equation for equilibrium, for the conditions of joint deformation and for the conditions of flow). It has to be noted that in its rigidity-plastic set-up the problem is meaningless, while in the elastic-plastic set-up the problem on the optimal heterogeneity of the material appears to be trivial. Its solution follows at once, as soon as the conditions of flow have been derived and recorded for the components of the stresses found for the elastic problem. In particular, the examples investigated by the author only yield data already known through Lame's solutions. The author's formulas for radial stresses actually coincide with Lame's formulas. The formulas for the limits of flow are also correct. However, the formulas for the tangential stresses are faulty. G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1697. Biderman, V. L., Calculation for deformations inside pneumatic tires (in Russian), *Trudi N.-i. In-ta Shin. Prom-sti* no. 3, 76–105, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13442.

Author determines the deformations and stresses inside a pneumatic tire when being inflated. Before inflation the inside of the tire has the appearance of a tore-shaped vessel. After inflation it takes the form of a body of rotation with the profile of an arc of the meridian, corresponding to the profile of the tire and the rim. Equations are derived for the equilibrium and the deformations; these are solved numerically by the method of successive approximations. The principles found for the determination of the stresses agree well with the experimental. The experimental procedure is not described. The conditions are established which cause the appearance of folds in the inside of the tire when the pneumatic tire is being assembled. These conditions are confirmed by experiment. Simplified methods of calculation for the inside of the tire are given with dimensions characterizing tires for use in freight-carrying lorries. V. I. Feolos'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1698. Bozhenko, V. S., On the influence of internal radial slots of a circular saw on the distribution of stresses (in Russian), *Trudi Vses. Zaochn. Lesotekhn. In-ta* no. 2, 163–166, 1956; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13005.

A circular saw with radial slots, used in the timber-milling industry, is examined as a rotating disk of constant thickness with a central opening, consisting of three concentric regions: two wheels adjacent to the inner and outer contour, and the intervening region containing the radial excisions. The investigation of the stressed state of the disk is carried out by Galerkin's approximate method, by means of which the stress functions were selected in the form of polynomes with coordinated functions, which are special solutions of Laplace's equation and a biharmonic equation. The results of the calculation are given in the form of a diagram of the surrounding stresses on different radii for two disks, having four radial excisions with a width equal to zero (cuts along straight lines), and differing from each other by the length of these cuts; here, the concentration of the surrounding stresses is disregarded. It should be noted that no expressions are furnished for the stress functions, with the consequence that it is not clear how author satisfies the boundary conditions and the conditions at the place of costresses in the regions without a corresponding selection of functions. The appearance of compressive peripheral stresses above the radial excisions is also left unexplained. A. D. Kovalenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Buckling

(See also Revs. 1666, 1691, 1701)

Book—1699. Rzhanitsyn, A. R., The stability of equilibrium of elastic systems (in Russian), Gostekhizdat, 1955, 476 pp. 15r, 30k; *Ref. Zb. Mekh.* no. 10, 1958, Rev. 11709.

Problems are studied regarding the elastic stability of different beams and, in part, of plates. General questions in the theory of stability are examined and the simplest problems for systems with one or several steps of freedom are solved: investigations are made of the system's energy, of the curves for the state of equilibrium, of the forms of losses of stability. Analyses are carried out by means of examples of the following: a mass on an elastic foundation, a floating body, a strongly tensed bar and shell, etc. The stability of straight bars is worked out, among others, the case of the continuous bar on stiff and elastic supports; the method of initial parameters is explained on the basis of matrix computation. The analytical and graphical approach to longitudinal-transverse deflection is investigated. A brief exposition is given of the known methods for evaluating the stability of bars of variable section. A calculation is put forward for bars beyond the limits of elasticity; the influence of the form of the transverse section on the modulus of longitudinal bending is examined; the behavior of the "ideal double-I" form is worked out. The characteristics of bars on elastic foundations are discussed. The theory is enunciated of the calculation for composite beams with stiff and flexible joints. A brief account is given of the stability of plane round rods in their plane. An investigation is made on the loss of stability of thin plates of different outlines in plane.

I. K. Snitko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1700. Malyutin, I. S., Buckling of a bar beyond the elastic limit (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 112–116, Aug. 1958.

Paper discusses the stability problem of a straight bar subjected to compression. Study is made both in the plastic and elastoplastic ranges with the aid of the Bubnov-Galerkin variational method. Numerical results are found by particularizing the elastic constants and are in good agreement with experimental data.

P. P. Teodorescu, Roumania

1701. Goldberg, J. E., and Lenzen, K. H., Roller fixtures for pin-ended column tests, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 191–194, 1958.

Simple cylindrical heads for testing columns approximately in the pin-ended condition are described, and the elementary principles governing their design are reviewed. The factors which may motivate the decision to test columns in the pin-ended rather than in the flat-ended condition, and the advantages of cylindrical heads over spherical heads are discussed briefly.

From authors' summary

1702. Skryabin, A. I., Stability of rectilinear bars with stiffness varying in jumps (in Russian), *Trudi Mosk. In-ta Inzh. Zh.-d. Transp.* no. 91, 77–90, 1957; *Ref. Zb. Mekh.* no. 10, 1958, Rev. 11682.

Characteristic equations are derived for the longitudinal deflection of a bar with rigidity varying stepwise with 2, 3, 4 and 5 segments. The sequence is given for the composition of the characteristic equation with an arbitrary number of segments. A table is constructed of the critical loads for a bar with three segments of identical length. It is demonstrated how to determine the critical force of a bar with a continuously changing rigidity by [replacing it with] a stepped bar, inscribed and described as approximating to the given bar. This is illustrated by a numerical example of a bar, clamped at one end with a rigidity varying linearly with a ratio of the rigidities of the upper and lower ends of the bar equal to 0.4.

P. A. Stepin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1703. Austin, W. J., Yegian, S., and Tung, T. P., Lateral buckling of elastically end-restrained I-beams, *Trans. Amer. Soc. Civ. Engrs.* **122,** 374–388, 1957.

Authors present an analysis of critical lateral loads and corresponding critical bending stresses at midspan for prismatic I-beams having equal, linear, rotational restraints at each end. The beam is assumed loaded in the plane of the web by vertical forces. Both uniform loading and concentrated load at midspan are treated. Application of each load is considered at three positions, namely, on the top flange, at the centroid, and at the bottom flange. The appropriate stability equations were solved numerically using successive approximations. Integration was effected using twenty-four equal divisions in length of the beam. Numerical computations were made on the Illiac digital computer using ten hours of calculation time. Charts and tables are presented giving critical loads and stresses for a wide variation of pertinent parameters. A very complete example is worked out demonstrating the usefulness of the results.

Reviewer believes this paper presents an excellent example of how digital computers can be set up to solve general problems whose results can be made useful for many not having access to a computer.

R. B. Grant, USA

1704. Mansfield, E. H., On the buckling of certain optimum plate structures with linearly varying thickness, *Aero. Quart.* **10,** 2, 145–148, May 1959.

Author contends that for local buckling plates whose thickness tapers linearly to zero across the section buckle at higher loads than plates whose sections have any other smooth variation of thickness. Analysis is based on differential equation of plates which includes variable flexural rigidity. Solution is restricted to a special class which satisfies the equations $\sigma_x = G\alpha^2$, $\nabla^2 w = 0$, where σ_x is the normal stress component in the longitudinal direction, G is the shear modulus, α is a constant which characterizes the plate and w is the deflection perpendicular to the plate middle surface.

Reviewer notes that since the differential equation describing the plate behavior is of fourth order, the restricted solution employed does not ensure *a priori* that the critical load so obtained is the minimum critical load.

A. P. Boresi, USA

1705. Caldwell, J. B., Elastic instability of stiffened sheet under compression reacted by shear, *J. Roy. Aero. Soc.* **63,** 582, 366–367 (Technical Note), June 1959.

The buckling of a sheet stiffened by longitudinal and transverse stiffeners due to a compressive line load along one edge and reacted by shears along the two perpendicular edges is solved by the energy method. With slight changes in the parameters the results are applicable to an unstiffened sheet. The writer believes this to be valuable addition to set of panel buckling cases previously solved.

J. A. Cheney, USA

1706. Benthem, J. P., Experiments on the post buckling behavior of simply supported panels that change in thickness across the bay, Nat. LuchtLab. Amsterdam TM S. 522, 64 pp., Mar. 1958.

A series of 2024 ST aluminum-alloy plates approximately 27.5 inches (700 mm) long, 0.039 (1 mm) thick and having 3 bays, each 6 inches (150 mm) wide, were tested in compression and the stress-strain curves determined for both the pre- and postbuckling regions. The edges of each bay were reinforced by additional strips which were cemented to the plate and the bay was defined

by a frictionless line support which permitted angular rotation and axial motion but restrained against motion perpendicular to the plate. It was shown by these tests that, with a proper distribution of material, a considerable increase in material effectiveness can be realized. Although the major results of this series of experiments are what one would expect, the most valuable information presented is the complete average stress versus average strain curves for the specimens, which may be of considerable value to others investigating postbuckling behavior of stiffened sheet panels. E. E. Sechler, USA

1707. French, F. W., and Patel, S. A., Creep buckling of cylindrical shells subjected to uniform axial compression, AFOSR TN 59-538 (Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech., PIBAL Rep. no. 489; ASTIA AD 215 555), 18 pp., May 1959.

The axially symmetric creep buckling of a circular cylindrical shell is investigated. A sandwich shell analogy and a biaxial creep law are used in the analysis. Two simultaneous, nonlinear differential equations are found to govern the stress distribution in and the displacement of the cylinder. A numerical example using these equations is carried out, and the results are presented in the form of curves. From authors' summary

1708. Kurshin, L. M., On stability of a shallow cylindrical sandwich shell in compression (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 97-100, Aug. 1958.

Author derives, on the basis of Lagrange's principle, a system of three nonlinear equations for finite deflections of shallow circular cylindrical shell of sandwich construction under lateral and axial loads. Hypothesis of Kirchoff-Love for the facings is supposed to be fulfilled; the only assumption for the core is that the translations are linearly distributed along the thickness of the shell and the normal fasers are inextensional.

The system is solved for the case of simply supported square panel in axial compression. The deflections are chosen in the form of one half-sine wave in both directions.

Characteristic load-deflections are analyzed from the point of view of different rigidity of the core with regard to normal stresses and shear stresses. Author shows that the ratio of upper buckling load to minimum buckling load (extreme values of the graph) decreases with the reduction of the rigidity of the core with regard to normal stresses, but increases with the reduction of the rigidity with regard to shear stresses. For the sandwiches with average rigidities of the core the mentioned ratio appears to be smaller than that for the homogeneous panel of the same thickness. I. Hlavacek, Czechoslovakia

1709. Hult, J., Creep buckling of plane frameworks, *Trans. Roy. Inst. Tech., Stockholm* No. 136 (*Mech. Engng.* no. 1), 31 pp., 1959.

Creep buckling has been discussed many times in the literature and the model invariably studied, for simplicity, is the column with hinged ends. In this publication, author attempts to extend the analysis to include columns with end restraints such as may be imposed by other members of a framework.

To introduce the problems associated with statically indeterminate construction, author considers a rigid bar hinged at one end and with axial compressive load at the other end. The loaded end is restrained by two springs which undergo creep as well as elastic deformation.

The complexity of exact solution for a practical problem is then pointed out by studying a two-member framework which consists of an elastic column and linearly viscoelastic beam.

Turning to nonlinear creep, author considers only H-section columns and indicates the mathematical difficulty which limits exact solution. The concept of the "creep hinge" is then introduced as an approximation to the actual behavior. The creep hinges are placed at the ends and centers of bars since these are locations in which the deformation is concentrated. The creep hinges, which are conceived as a spring with elastic and creep behavior in place of each flange, are given numerical magnitude by matching end point slopes.

Author shows that, for two elastic buckling problems, the calculation made using hinges considerably underestimates the buckling loads. However, it is indicated that for creep calculations the error would be much less.

Reviewer considers that the paper is a significant contribution and worth the attention of these interested in creep buckling. I. Finnie, USA

Vibrations of Solids

(See also Revs. 1598, 1629, 1726, 1836, 2027, 2062, 2102)

1710. Laasonen, P., Eigenoscillations of an elastic cable, *Quart. Appl. Math.* **17,** 2, 147-154, July 1959.

Author considers small oscillations about the equilibrium configuration of an elastic cable (string) hanging from two supports under its own weight. By a perturbation analysis, he obtains a set of ordinary variable-coefficient differential equations for the eigenfunctions and natural frequencies. These are shown to be self-adjoint, and an iterative solution is displayed in which the $i+1$ iterate is obtained by a double integration over the ith iterate and auxiliary functions. A reference is given for a convergence proof of the iteration, but no numerical calculations with the iteration are attempted. The last section of the paper is devoted to the shallow cable. Although it is not explicitly so stated, this section considers small oscillations about the parabolic approximation to the catenary. Author succeeds in solving this case directly, and curves of the natural frequency as a function of a dimensionless parameter embodying the cable properties are shown.

Author fails to mention an important physical result that this analysis yields. It has long been observed that telephone and power cables do not oscillate transversely like the fundamental mode of a string, that is, with nodes at the poles and a maximum vertical motion at midspan. Rather, they exhibit a "sloshing" motion, with little vertical movement at midspan, and a to-and-fro horizontal transfer of cable from one side of the span to the other. This is just the author's "group II" motion. The last section of the paper indicates that for sags y greater than $y = (\pi^2 \mu g L^4 / 128 EA^{\frac{1}{3}})$ (μg = weight per unit length, L = span, EA = tensile modulus) this "sloshing" mode does indeed become the gravest transverse mode. Some computations by the reviewer on real cables indicate that the sag-to-span ratio at which this occurs is small (for example, for a 300-ft span steel cable $y/L = 0.014$). E. E. Zajac, USA

1711. Mitra, M., The disturbance due to periodic surface traction in a semi-infinite medium of varying elasticity and density, *Geofis. Pura Appl., Milan* **41,** 3, 86-90, 1958.

The shear displacement due to a transverse periodic surface traction on a semi-infinite elastic solid, in which the rigidity and density vary exponentially with the depth, has been obtained. The normal modes are calculated for high frequencies, and the surface displacement obtained numerically in a particular case for a low frequency. From author's summary

1712. Fastov, N. S., The theory of elastic aftereffect (in Russian), *Sb. Trudi In-ta Metalloved. i Fiz. Metallov Tsentr. N.-i. In-ta Chernoi Metallurgii* **5,** 583-594, 1958; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11548.

The problem of the torsional vibrations of a homogeneous and isotropic round rod is investigated; the top end of the rod is im-

movably fixed, while to the lower, in a moment of time $t = 0$, a sudden torsional pair of forces is applied, the forces having a constant moment. The basis of the investigation is the integral relationship of a succession type with a nucleus in the form of an aggregate of exponential nuclei. The equation of motion having the form

$$\rho\ddot{\varphi} = \mu \frac{\partial^2 \varphi}{\partial z^2} + \sum_{\alpha=1}^{\Lambda} B_\alpha \int_0^t e^{\frac{t'-t}{\tau_\alpha}} \frac{d^2\varphi}{dz^2}\, dt'$$

(where ρ, μ, B_α, τ_α are parameters, φ the angle of rotation of the transverse section of the rod) is solved by the operational method. It should be noted that in the investigated problem the elastic aftereffect manifests itself in the asymptotic approximation of the angle of rotation of the rod (after the damping down of the elastic vibrations) in relation to its own position of equilibrium.

M. I. Rozovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1713. Takahashi, S., Free lateral vibrations of rectangular bars with many circular holes, *Bull. JSME* **1**, 3, 210–215, Aug. 1958.

Free lateral vibrations of rectangular bars with many circular holes are studied, in which the vibrations are produced in the direction perpendicular to the axes of holes. The boundary conditions considered are: one end built-in and the other free; built-in ends; hinged ends; and one end built-in and the other hinged. The method used is to determine the coefficients of normal functions according to Ritz, and it is possible to obtain the frequencies of any mode. Numerical calculations are carried out for the bars with one end built-in and the other free with respect to the first and second modes, and a part of the calculated results is compared with experiments. From author's summary

1714. Arkhipov, K. A., Determination of the frequencies of elastic vibrations in continuous beams and simple frames by the method of nodal points (in Russian), *Trudî Leningrad Tekhnol. In-ta* no. 38, 101–116, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13059.

A transposition is given from Gogenemzer and Prager's book on the theorem of the three moments and of the method of nodal points, and an attempt is made to derive an equation for the frequencies of a doorway frame with bracing of gradually variable rigidity. However the setting for the problem is wrong, inasmuch as the nodal point, without justification, is made to coincide with the place where the bracing changes in section and, further, no account is taken of the parameter of the collar beam.

A. G. Barchenkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1715. Brady, W. G., and Targoff, W. P., Uncoupled torsional vibrations of a thin, twisted, rotating beam, WADC TR 56-501 (PB 131 237; ASTIA AD 130 786), 24 pp., June 1957.

A method is presented for computing uncoupled torsional vibration frequencies for pretwisted rotating beams such as propeller blades. The analysis included the torsional loading due to centrifugal forces, and the effects on torsional stiffness of beam pretwist and static torsional deflection. The equilibrium torsional deflection under rotation is computed by an iterative numerical integration process for a given rotational speed. For small torsional oscillations about the equilibrium deflection, the stiffness is linearized, and torsional frequencies computed by a procedure similar to the Holzer method.

From authors' summary by M. V. Barton, USA

1716. Yamamoto, T., On critical speeds of a shaft supported by a ball bearing, *ASME Trans.* **81**E (*J. Appl. Mech.*), 2, 199–204, June 1959.

Author points out that two kinds of critical speeds induced by a slight difference in the diameter of balls in a ball bearing appear in a rotating shaft supported by ball bearings. These two critical speeds have peculiar modes of vibrations which are determined by dimensions of ball bearings; one of them is motion of forward precession, the other is backward precession. Paper describes the cause of these critical speeds and the behavior of those vibrations.

From author's summary

1717. Thorkildsen, R. L., and Hoppmann, W. H., II, Effect of rotatory inertia on the frequencies of vibration of stiffened plates, *ASME Trans.* **81**E (*J. Appl. Mech.*) 2, 298–300 (Brief Notes), June 1959.

1718. Fletcher, H. J., The frequency of vibration of rectangular isotropic plates, *ASME Trans.* **81**E (*J. Appl. Mech.*) 2, p. 290 (Design Data and Methods), June 1959.

1719. Hagrup, J. F., and Bronner, N.-E., Dynamic stability of chimneys (in Swedish), *Tekn. Tidskr.* **89**, 21, 547–552, May 1959.

Authors give an account of the design of two stacks, both about 85 meters tall, considering their dynamical behavior. Amplitude of vibration is estimated from energy considerations.

F. I. Niordson, Denmark

1720. Zhodzishskii, G. A., Influence of uneven heating on the frequencies of natural vibrations of saw disks of constant thickness (in Russian), *Trudî Leningrad Lesotekhn. Akad.* no. 82, part 2, 149–164, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13058.

A study is made, using the Bubnov-Galerkin method, of the frequency of natural transverse vibrations of a disk of constant thickness, subjected to an axially symmetrical uneven heating, the disk being rigidly fastened along its inner contour and free along the outer contour because of reacting forces. As a differential equation for the problem use is made of the equation for the free transverse vibrations of a round plate of constant thickness under the action of tension forces symmetrically distributed in its central plane, the forces being conditioned by uneven heating, while an approximate expression for the deflection is selected in the form

$$w = a_0(r-a)^2 \left(1 + \frac{B_1}{b} r + \frac{B_2}{b^2} r^2\right) \sin(k\theta + \theta_0) \sin(\omega t + \alpha_0)$$

where r, θ are polar coordinates; a, b are radii of the inner and outer contour; k is the number of rotations of the joints; ω is the angular frequency of the vibrations; α_0, θ_0 are constants, determinable from the initial conditions; B_1, B_2 are constants, determinable from the boundary conditions on the outer contour (the boundary conditions on the inner contour are automatically satisfied); a_0 is an arbitrary constant. The distribution of the temperature along the radius of the disk is taken to follow the stepped principle. An expression is put forward for all the integrals which have a place in the derived formula for the calculation of the natural frequencies. The case of $k = 0$ for an evenly heated disk is compared with the known precise solution of the problem on the natural vibrations of a round plate of constant thickness and possessing Bessel functions. In the example of the calculation, determinations are made of the natural vibrations of a circular saw disk with $k = 0, 1, \ldots, 6$ and with differences of temperature between the external and internal contours of 0, 15, 30, 45, 90°, and also of "critical temperatures" corresponding to zero frequency with different forms of vibration and the responding losses of stability in the circular saw disks of plane form. It is shown that with $k = 0$ and $k = 1$ the frequencies of the evenly heated disk increase and in conjunction with this (fast) loss of stability is not possible (the critical temperature is negative); with $k > 1$ the frequency of the disk decreases and there are "critical" temperatures. It should be recorded that the selected expression for the deflection only permits the determination of the lowest frequency for

each fixed (value of) k; investigations of frequencies of higher forms of vibrations with several nodal periphery are not taken up in the paper.

A. D. Kovalenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1721. Hoppmann, W. H., II, Flexural vibrations of orthogonally stiffened cylindrical shells (in English), 9th Congrès Intern. Mêcan Appl., Univ. Bruxelles, 1957; **7,** 225–237.

Author applies orthotropic plate theory to vibration of cylindrical shells with circumferential stiffeners. Orthotropic elastic constants are experimentally determined from sample plates. Calculated frequencies are compared with experimental values. Method was checked on uniform cylinder. Reduction of frequencies by rotating inertia of stiffeners was very apparent.

R. Plunkett, USA

1722. Burquest, M. O., and Carpenter, J. E., Structural and vibrational characteristics of WADC S-2 model propeller blades, WADC TR 56-28 (PB 131 370; ASTIA AD 130 785), 84 pp., June 1957.

The structural and vibrational characteristics of a three-bladed configuration of WADC S-2 model propellar blades have been experimentally and analytically determined.

The test blades were instrumented with wire-resistance strain gages and were rotated, at various positive and negative blade angle settings, up to speeds of 8000 rpm. The blades were vibrated in the fundamental bending mode, second bending mode, and the first torsion mode at various pitch angles and rotational speeds, and the strain gage signals were recorded. Experimental data were also obtained of the steady strains produced by centrifugal force as well as of the blade damping for the various vibratory test conditions.

Concurrently with the experimental program, the blade vibratory characteristics were analytically determined for several combinations of blade angle setting and rotational speed. Excellent correlation was obtained between the experimental and analytical results.

From authors' summary

1723. Hudson, D. E., and Housner, G. W., Structural vibrations produced by ground motion, *Trans. Amer. Soc. Civ. Engrs.* **122,** 705–721, 1957.

Dynamic loads on a steel-frame mill building caused by a large quarry blast have been measured and used as a basis for improving the strength-weight efficiency of such structures. The dynamic response has been computed by means of simplified models. Ingenious use of dynamics theory supplements the somewhat limited test facilities and correlates measured ground motion with the building floor acceleration response.

E. G. Fischer, USA

1724. Painter, G. W., Dry-friction damped isolators, *Prod. Engng.* **30,** 31, 48–51, Aug. 1959.

Though dry-friction damped isolators can outperform the better known "viscous" type, they cause trouble at higher frequencies unless properly selected. With curves comparing both types, author supplies his own equations for predicting vibration-transmissibility characteristics.

From author's summary

Wave Motion and Impact in Solids

(See also Revs. 1723, 1739, 1749, 1760, 2061, 2062)

1725. Turnbow, J. W., and Ripperger, E. A., Strain-rate effects on stress-strain characteristics of aluminum and copper, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept, 1959; Austin, Texas, Univ. Press, 415-440.

Disadvantages of direct and indirect methods used for obtaining stress-strain relations at high strain rates are discussed. A dynamic loading device designed to overcome some difficulties is described. Load was applied by a falling mass; force was measured with a dynamometer supporting specimen; strain was measured by strain gages placed on specimen. Specimens were tubular type with different lengths. Strain rate varied from 0 to about 2000 in./in sec. Dynamometer did not provide satisfactory measurements due to reflections, resonances and lack of planeness of impact. Further measurements with an airgun and a Hopkinson pressure bar, instrumented with strain gages, provided data of higher precision (this device is not described in paper). Buckling of specimens occured only after relatively large uniform strain had been produced. Results: For a 6061-T6 aluminum alloy, heat treated and artificially aged, rate of increase of ultimate stress is 5.4 psi/in/in sec, with a static value of 48 kpsi. For a partially annealed 99% copper, ultimate stress increases from 48 kpsi to 60 kpsi at a strain rate of 200in./in sec, then uniformly with strain rate. Effective elastic modulus of both materials seems to decrease with increasing strain rate, but this result is presented with reservation. Data are not sufficiently reliable to prove validity of Malvern linear strain rate theory.

A. Kochendorfer, Germany

1726. Treitel, S., On the attenuation of small-amplitude plane stress waves in a thermoelastic solid, *J. Geophys. Res.* **64,** 6, 661–665, June 1959.

Using the irreversible form of the second law of thermodynamics the author derives the equations governing the motion of the stress wave and local changes of temperature in an elastic solid with finite thermal conductivity. It is shown that the attenuation coefficient is proportional to the square of the frequency of the traveling stress wave and, further, depends linearly on the thermal diffusity and on the negative third power of the compressional wave velocity. Numerical values of the attenuation coefficient computed for two very different materials, copper and rock, prove that the derived approximate formula holds for all frequencies of physical interest.

V. Kopriva, Czechoslovakia

1727. Graham, R. A., and Ripperger, E. A., A comparison of surface strains to average strains in longitudinal elastic wave propagation, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Tex., Sept. 1959; Austin, Texas, Univ. Press, 382-395.

This paper deals with the transmission of transient strains along a round bar. The strains were produced by the longitudinal impact of small balls on the end of the bar. The pulses had durations of 1.8 to 4.8 μsec. The authors compared the output of a quartz crystal sandwiched between two parts of the bar with the output of SR4 strain gages cemented on the surface of the bar. Unforutnately, neither the quartz crystal nor the strain gages were calibrated. Similar work had been conducted previously by Cunningham and Goldsmith [*Soc. Exp. Stress Anal.* **16,** no. 2, p. 153] on rectangular bars subjected to impacts of somewhat longer duration. The authors conclude that for long wavelength components of the pulse, the surface strain measurements by SR4 gages agree well with the average signals obtained from the crystal.

A. J. Durelli, USA

1728. Kuo, S. S., Bending waves in free-free beams, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 457-467.

A solution is given for the Timoshenko beam equations for a moment input in the form of a ramp platform. Using the method of characteristics the equations are put in appropriate form for numerical integration. (See NACA Rep. 1173.) Integration is carried out by machine computer for several slenderness ratios, and a plot of values of moment are given versus time at fixed stations

along the beam. Also, the rise time of the moment is varied and this influence given in graphical form.

R. E. Beckett, USA

1729. Lovetskii, E. E., Similarity relations for an explosion in a plastic, compressible medium (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 120–122, Jan. 1958.

Based on A. S. Kompaneets' paper ["Shock waves in compressible plastic bodies," *Doklady Akad. Nauk SSSR*, no. 1, 1956], author elaborates diagrams which, in the case of an explosion in a very reduced spherical volume in the soil, give the dependence of the adiabatic gas coeffieient γ on the shock-wave radius, the dependence of the radial stresses and a time function on the cavity radius, and the dependence of the dissipated energy per unit volume on the initial position of this volume. This latter dependence is deduced on the basis of author's calculations which may also lead to the estimation of temperatures in the soil.

M. M. Misicu, Roumania

1730. Nardini, R., Wave fronts in magneto-elasticity (in Italian), *R. C. Semin. Mat., Univ. Padova* **28,** 2, 225–243, 1958.

Author applies the theory of characteristics in systems of the differential equations to show the existence of magneto-elastic wave fronts in an electrically conducting elastic body in presence of a magnetic field. The infinite electrical conductivity case is considered. The velocity of the wave front is calculated and particular types of waves are considered.

G. Sestini, Italy

1731. Rakivnenko, N. S., On impact on curved beams. I: Impact on a round ring (in Russian), Nauchn. Soobshch. Khar'kovsk In-ta Inzh. Zh. -d. Transp. no. 2, 44 pp., 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13061.

The theory is examined of impact on a round ring as one of the problems in the dynamics of curved beams. An investigation is made of the straight, plane, central impact on the ring, taking into account local deformation, on the assumption of a linear relation existing between the increase of local deformation and the force applied (on the analogy with the "coefficient of bedding down" for beams on an elastic foundation). Differential relations are put forward for the problem in symbolical form, and also the function of influence, expressing the radial displacements of points on the axis of the ring caused by the action of counterforces. An an example the case is examined of an impact on a ring made of phenolite in polarized light, studied experimentally by Tuzi and Nisida [*Scient. Papers Inst. Phys. Chem. Res., Tokyo*, **9,** no. 149, 1928]. It is noted that the theoretical values of the maximum stresses in the ring on impact differ but little from the experimental. The graphs given lighten the task of solving the problem, leading it to the sum total of three terms of a trigonometrical series. The work could be used for the dynamic calculations for arches, bridges and roofs, chain components, lugs, etc.

A. F. Rozhnyatovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1732. Lamb, J., Redwood, M., and Shteinshleifer, Z., Absorption of compressional waves in solids from 100 to 1000 Mc/sec, *Phys. Rev. Letters* **3,** 1, 28–29, July 1959.

Absorption coefficients for quartz, fused silica, germanium and silicon as a function of frequency are presented in the form of log-log plots. Results indicate that attenuation for these materials varies almost as the square of the frequency. Frequency range is far beyond frequencies of usual interest in elastic wave propagation studies. E. A. Ripperger, USA

1733. Latter, A. L., Martinelli, E. A., and Teller, E., Seismic scaling law for underground explosions, *Physics of Fluids* **2,** 3, 280–282, May–June 1959.

An heuristic argument is presented which, according to the authors, explains certain observed relations between ground motion and energy release of underground nuclear explosions.

G. W. Housner, USA

Soil Mechanics: Fundamental

(See also Revs. 1657, 1662)

1734. Sonntag, G., Influence of anisotropy of rock on the stresses in the environment of tunnels. Parts I and II (in German), *Bauingenieur* **33,** 8, 287–294, Aug. 1958; **33,** 9, 344–351, Sept. 1958.

Author analyzes the state of stress and deformation about straight tunnels with circular, elliptical and square sections through elastic anisotropic media. Two different cases of anisotropy are considered. The medium is first regarded as a homogeneous solid with different elastic properties in every direction through a point; in the second case the medium consists of a succession of similar couples of layers, each layer of a couple having different elastic properties. Author gives the solution of this last problem in the case where friction forces acting on the contact faces fully prevent relative displacements of the layers.

Formulas are worked out for different orientations of the external pressure with respect to the directions of the layers and of the major modulus of elasticity; the influence of ratio between major and minor modulus of elasticity is also explored with special reference to the instances where the stresses attain their maximum values.

When the single layers are free to move with respect to each other the problem cannot be treated analytically; therefore author uses experience with photoelastic models and studies the case of layers with same elastic properties and also the case of altemate layers with different properties. By means of data contained in paper it is readily possible to estimate the remarkable differences existing between the states of stress and deformation about tunnels in the most common cases of anisotropy of rocks and those taking place in ideal elastic isotropic solids.

R. Jappelli, Italy

1735. Molokovich, Yu. M., Determination of the field of pressure in strata of variable permeability (in Russian), *Uch. Zap. Kazansk. In-ta* **117,** 2, 120–124, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11323.

The plane steady field of pressure p in a layer c with variable permeability $k(x,y)$ is determined. The solution for function $u = (p - p_0)\sqrt{k}$, where p_0 is the pressure on the feed contour, is presented in two parts. The first consists of the sum of harmonic functions having characteristics on the wells. For the second, with the aid of Green's function, an integral equation is obtained, which it is proposed to solve by the method of successive approximations. For the second feed contour the solution contains two infinite series of functions, where, in the second series, each successive function is obtained by integration around the expression containing the previous one. The conditions of convergence of the second series are indicated. V. A. Maksimov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1736. Meschyan, S. R., On the principle of superposition for the creep deformation of cohesive soils under compression (in Russian), *Doklady Akad. Nauk ArmSSR* **25,** 4, 171–176, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11634.

is noted that the cohesion of soils while (remaining) under load grows with the passage of time. This phenomenon is called "ageing" by the author, on analogy to the "ageing" of concrete. The compressibility of a "shengavitski" type of clay with different "growth" increments of the test samples was investigated, a special form of compression apparatus being used for the purpose. To one series of samples a gradually stepped increase of load was applied. To other series of samples, the "growth" of which varied, the load was applied once. Based on the tests carried out the author makes a deduction to the effect that the equations for ageing and creep proposed by N. Kh. Artuyunyan for concrete ["Some questions in the theory of creep," Moscow, Gostekhteorizdat, 1952, pp. 40–42] can be applied to soils. The principle for superposition of deformation of creep can, when so doing, be recorded in the form of an equation

$$l_n = \sum_{i=1}^{i=n} F[_i(\tau_l)] \left(C + \frac{A}{\tau}\right) \{1 - \exp[-\gamma(t - \tau)]\}$$

where l_n is the deformation in the moment of time t, $F(P)$ is the stress function, determinable by experiment; P_i the load increment applied in the moment of time τ_i; C, A and γ parameters.

N. I. Malinin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1737. Meshkova, L. B., Some problems of limiting state of equilibrium of geological strata (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 156–159, July 1957.

Two problems are considered:

(1) A physical medium (rock) has a constant section xOB, the curvilinear wall OB is free (normal stresses equal to zero) and in steady equilibrium. Along the horizontal boundary Ox, a uniform pressure acts, defined in such a way that a curve of rupture OA appears inside the rocks.

Beginning with differential equations of equilibrium (of hyperbolic type and with real characteristics) and using the boundary conditions on OB and OA, author gives the equations in finite form of these two curves and the expressions of the stresses in the rock. He assumes that the lines of shearing stress are cycloids.

(2) Similar problem, but the free semiarch OB is replaced by a rigid wall of given shape. Author calculates the contact stresses along this rigid wall. An application to the case of a circular semiarch OB is considered. V. N. Baranov, France

1738. Kravchenko, I. K., An accelerated method for determining the calculation characteristics of plastic soils (in Russian), *Stroit. Prom-st'* no. 1, 32–35, 1958; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13177.

An accelerated method is proposed for calculating (without recourse to the corresponding laboratory tests) the compressibility and the calculation resistance of the soil below the foundation, and also the friction and cohesion for "pure" clay soils and for mixtures of clays with gravel and shingle. In order to determine the calculation characteristics by the proposed method it is necessary to know in advance the volumetric weight and the humidity of the monolita of undisturbed structure, the amount of clay soil in the monolita and its maximum molecular moisture capacity. Calculation formulae and graphs are given for determination of the settlement of the soil under the foundation, the resistance of the soil to compression by a stamping machine, the friction and cohesion in a clay soil and in a mixed clay and gravel soil. Examples are furnished of the determination of the calculation characteristics of five Vorkutinsk soils. S. R. Meschyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1739. Romashov, A. N., Rodionov, V. N., and Sukhotin, A. P., On an explosion in an unbounded compacting medium, *Soviet Phys.-Doklady* **3,** 6, 1283–1286, June 1959. (Translation of *Dokladl Akad. Nauk SSSR (N.S.)* **123,** 4, 627–630, Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Explosion propagation in soil depends on irreversible medium deformations. Experimental studies were conducted on sandy soil of 1.5 g/cm³ density and 6% moisture content, with explosive charges of 1.0, 6.0 and 24.0 g. Propagation and motion were considered spherically symmetrical by eliminating influence of free surface. Measurements were made of the celerity of wave front and of displacements of spherical layers at various radial distances from the explosion center by inserting a 0.1 mm thick metallic foil that moved together with soil. Curves were plotted of displacements in mm versus time in microseconds, from which particle and wave velocities were determined. Experimental data show that kinetic energy is about 2–3% and energy irreversibly transformed into heat in the soil is about 70–80% of total supplied energy. Equations of motion for spherically symmetric motion are integrated and compared to experimental relationships.

A. Balloffet, USA

Soil Mechanics: Applied

(See also Rev. 1723)

Book—1740. Yoder, E. J., Principles of pavement design, New York, John Wiley & Sons, Inc., 1959, xvi + 569 pp. $13.25.

This is a comprehensive, well-illustrated textbook covering principles of highway and airport pavement design, with their applications and comparison of current design procedure. It contains problems and selected references. Basic knowledge of soil mechanics and materials testing is assumed.

Under fundamental principles are included stresses and displacements in subgrade, base and surface of both rigid and flexible pavements, considering size, location and repetitions of static and moving loads. Climate and pumping are also considered.

Under properties of pavement components are presented soil formations, testing, classification, and stabilization and the effect of moisture and density on strength and volume change. Properties of bases, shoulders and bituminous surfaces are also covered.

Design methods currently used by various agencies are presented with applicable charts and are compared with some critical evaluation. Presentation is rounded out with chapters on surveying pavements for performance, evaluation, and design development, and on maintenance and strengthening by overlays.

E. S. Barber, USA

1741. Yaroshenko, V. A., and Berezaitsev, V. G., Stability of sand beds below deep foundations (in Russian), Papers for the 4th International Congress on Mechanics of Soils and the Construction of Foundations, Moscow, Akad. Nauk SSSR, 1957, 143–152; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11593.

This is an experimental and theoretical investigation of the stability of deeply and shallowly laid foundations on a sandy bed. The experiments show that the initial phase of deformation appears in the basic phase of compression. In this phase there is no intensive sagging and lateral displacement of the soil endangering the normal working of the construction. The next phase is characterized by the formation of a compacted nucleus which separates from the surrounding soil by surface disruption. It is in this phase that significant, rapidly-extending sagging develops, which is capable of destroying the normal working of the instal-

lation. The appearance of the boundary state links up with the moment of completion of the formation of a compacted nucleus consisting of two parts, the elastic and the inelastic. This moment corresponds to: the general shear of the soil adjacent to the foundation along the surfaces of slip, both in the presence of bulging and in the absence of bulging; an intensive increase in the sagging at the expense of the compacting of the surrounding soil. Different cases are described of the boundary condition of a sandy bed appearing in the stirred up or compacted sand as the result of deeply or shallowly laid foundations. The theoretical values of the bearing capacity, determined on the basis of the theory of boundary equilibrium, were found to closely approximate the experimental.

G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1742. Murdock, L. J., Some problems in the practical application of soil mechanics to foundation engineering, Proc. Midland Soil Mech. Found. Engng. Soc. **2,** Pap. no. 8, 18 pp., Nov. 1957.

1743. Lobanov, I. Z., A more accurate method of calculating the final settling of engineering structures (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk, Dnepropetr. In-ta Inzh. Zh.-d. Transp., 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2312.

Processing of Metals and Other Materials

(See also Revs. 1617, 1618, 1659)

Book—1744. Unksov, E. P., Engineering methods of calculating the forces when treating metals by pressure (in Russian), Moscow, Mashgiz, 1955, 280 pp. + illus.; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11546.

The monograph is devoted to investigations of the stresses and forces when metals are being pressure-treated. An exposition is given of the modern concepts on the process of the plastic deformation of metals. The relationships are indicated of the mechanical properties and structure of the metal to the deformation. A description is furnished of the investigation by the optical method of the stressed state when forging prepared specimens of round and square sections. The bases of the theory of the stressed state are given. Different theories of plasticity are described and also methods for solving practical problems on the determination of the forces of deformation (the characteristics method, the Smimov-Alyaev method). The basic position of the engineering method rests on the following considerations: all schemes of the stressed state lead to either the plane or to the axially symmetrical deformed state; the assumption is made of the uniform distribution of normal stresses along one of the coordinates; when solving the equations of equilibrium use is made of the experimentally established boundary conditions. In subsequent chapters of the book questions are examined dealing with the experimental investigations of boundary conditions and the theoretical calculations for the stressed state and forces with the following processes of pressure-treatment in operation: sagging without widening of wedge-shaped forgings under plane inclined plates, free sagging of cylindrical forgings under plane parallel plates, a thick-walled ring under the action of internal pressure, an open seam, extrusion of turbine blades, rods, tubes. As experimental methods the following were exemplified: the method of the coordinate network with the help of carbon transmitters of resistance, set in position along one line in the plate-punch, the method of photoelasticity, the method of flowing in metal into a narrow slit of the punch. For each process practical, technological advice is given and also calculation formulas for the pressure.

V. G. Osipov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1745. Friedewald, H.-J., Prestressing for punching and forming dies (in German), *VDI Forschungsheft* **25,** 472, 44 pp., 1959.

Prestressing is widely used in die-making in order to increase the loading capacity by pretensioning, to save material, to permit the use of exchangeable wearing parts, and to reduce die-making costs. By correctly computing the loading capacity and establishing the optimal proportions of wall thicknesses, tooling costs can be considerably reduced. The formulas for calculating prestressing with one and two shrink rings as well as the required shrink-fit measures and the permissible tolerances are given as a guide for designing. Important factors which have a bearing on the setup are analyzed by way of experiments, and methods discussed for measuring the radial pressures which act on the die in extruding and cutting.

From author's summary by H. Blok, Holland

1746. Colding, B. N., A three-dimensional, tool-life equation—machining economics, *ASME Trans.* **81** B (*J. Engng. Industry*), 3, 239–250, Aug. 1959.

Two equations are derived relating tool life, cutting speed and chip equivalent (a function of feed, depth of cut, nose radius and side cutting-edge angle). One equation is valid within prescribed limits of cutting speed and chip equivalent; the other equation is more general.

The general tool-life equation is combined with an expression for productivity in order to investigate the optimum combination of tool-life, cutting speed and chip equivalent.

B. W. Shaffer, USA

1747. Shimada, H., Studies of wheel center castings, *Bull. JSME* **2,** 6, 238–244, May 1959.

Description of riser dimensions for making cast-steel spoked wheels for railway equipment. Author concludes that Pellini's data should be modified for complex castings.

W. H. Sparing, USA

Fracture (Including Fatigue)

(See also Revs. 1598, 1628, 1773, 1774, 1776)

1748. Berry, J. M., Cleavage step formation in brittle fracture propagation, *Trans. Amer. Soc. Metals* **51,** 556–581, 1959.

Paper describes an experimental study of fracture in which single crystals of silicon-iron were cleaved in the [110] direction at a temperature of −196 C by driving a wedge into the base of a fine sawed notch. Micrographic examinations of the fracture surface and its profile are used to provide a description of some of the metallographic features of brittle fracture propagation in this material. Models suggesting the mechanism of propagation and the formation of cleavage steps are presented. Fracture starts at the base of the notch on numerous separated levels and as the cracks propagate they tend to join up with the formation of cleavage steps. Such cleavage steps are relatively large near the base of the notch and become smaller at further distances from the notch. Such steps are generated by local cleavage at large but specific crystallographic angles to the main cleavage plane. Plastic deformation in cleavage steps causes a plastic necking-off of flaps, plastic shearing-off and, proposed here, the creation of a twin-

parent crystal interface as a new cleavage plane along which brittle fracture can be propagated.

H. A. Lepper, Jr., USA

1749. Hendrickson, J. A., Wood, D. S., and Clark, D. S., The initiation of brittle fracture in mild steel, *Trans. Amer. Soc. Metals* **50**, 656–676, 1958.

Paper presents a combined analytical and experimental determination of local fracture stress in cylindrical notched specimens of annealed low-carbon steel. Testing temperature for fracture ranged from −110 to −200 F, and rate of nominal stress application from 10^3 to 10^7 psi/sec. Stress distribution in region of notch root obtained by elastic-plastic analysis reveals maximum at boundary of plastic deformation; this maximum at fracture was independent of temperature and stress rate. Authors conclude that influence of temperature and stress rate occurs only through effect on yield stress. Reviewer believes that the narrow (and low) temperature range, combined with very limited allowable gross plastic strain, represents only a small portion at the brittle and high-strain-rate end of possible range of behavior for 0.17% C–0.39% Mn steel. Other more recent work [U. of Ill. Structural Res. Series no. 183, Oct. 1959] demonstrates that threshold of influence of stress (strain) rate on brittle fracture may be much lower than hitherto thought. Thus authors' conclusions apply only to limited range. Assumption of isotropy and non-strain-hardening in plastic zone, if valid for these tests, is not in accord with other recent work on static fracture initiation in mild steel nearer service temperatures [*Weld. J. Res. Supp.* **38**, 10, 414s–424s, Oct. 1959] which shows dependence on highly localized, but severe, prestrain. Reviewer believes present results of significance to fracture theory, and apologizes for necessary introduction of *post factum* research results.

D. K. Felbeck, USA

1750. Pogodina-Alekseeva, K. M., and Pogodin-Alekseev, G. I., The brittleness of steel produced during testing and the means for revealing it, *Indust. Lab.* **24**, 2, 209–212, Mar. 1959. (Translation of *Zavod. Lab., USSR* **24**, 198–202, Feb. 1958 by Instrument Society of America, Pittsburgh, Pa.)

1751. Yositake, H., Fatigue strength of a bar with a cotter hole, *Bull. JSME* **2**, 6, 306–310, May 1959.

Rotating bending fatigue strengths of cylindrical shafts with cotter holes of various dimensions are reported. The fatigue strength reduction factors determined from these experiments are compared with theoretical stress-concentration values. As normally expected, fatigue strength reduction factors are significantly less than theoretical stress-concentration factors, but reasons for these differences are not discussed quantitatively. Author includes practical design suggestions for increasing fatigue strength of cotter holes by using appropriate radii for corners and ends of holes.

B. J. Lazan, USA

1752. Podstrigach, Ia. S., and Chaevskii, M. I., The influence of internal friction on the fatigue failure of cyclically deformed members, *Soviet Phys.-Doklady* **3**, 4, 830–833, Apr. 1959. (Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **121**, 2, 268–270, July–Aug. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

1753. Johnston, J. R., Weeton, J. W., and Signorelli, R. A., Engine operating conditions that cause thermal-fatigue cracks in turbojet-engine buckets, NASA Memo 4-7-59E, Apr. 1959.

A series of engine tests was conducted to definitely establish the failure mechanism of leading-edge cracking and to determine which portions of engine operation cause the failures. The types of operation in the respective tests included steady-state operation, rapid cycles of acceleration and deceleration, and cycles of starting and stopping. The results indicated that the cracks were initiated by thermal fatigue and were caused chiefly by engine starts. Crack initiation was accelerated by engine operation at rated speed and temperature and prevented by starting the engine gradually.

From authors' summary

1754. Salokangas, J., and Lehto, P., On the fatigue strength of a copper coating sprayed on steel bars (in English), Acta Polytech. Scandinavica (ME 6) no. 258, 21 pp., 1959.

The properties of sprayed copper, the influence of the steel surface on spraying and the corrosion-resistant influence of sprayed copper on steel were examined. The practical tests for investigating the fatigue strength of sprayed copper were carried out under laboratory conditions in a rotating-bending fatigue testing machine. A copper layer was sprayed on the surface of a steel test bar. The stress that could be sustained for 10^7 load cycles without producing a crack, visible under the binocular microscope, was regarded as the fatigue strength of sprayed copper. The effects that had occurred in the sprayed coating were examined under the binocular microscope during the fatigue test. On the basis of the observations made in the fatigue tests it could be stated that both the wire feed and the spraying distance were, within certain limits, inversely proportional to the fatigue strength of sprayed copper.

From authors' summary

1755. Ivanova, V. S., Diagram of the fatigue failure of metals, *Soviet Phys.-Doklady* **3**, 2, 378–381, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N. S.)* **119**, 1, 71–74, Mar.–Apr. 1958, by Amer. Inst. Phys., Inc., New York, N. Y.)

1756. Loginov, P. I., Investigation of the influence of momentary overloads of the resonance type on the fatigue strength of constructional steel (in Russian), *Trudi Leningrad Politekhn. Inta* no. 191, 70–86, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13572.

Curves for fatigue were obtained and also the relation of change in deflection of the end of the test sample in the process of testing at constant nominal stress. It was shown that the evolving of the relation of the magnitude of the deflection of the sample from the number of cycles of loading enabled one to make apparent three stages in the process of fatigue disruption: the initial hardening of the dangerous zone, the appearance of micro- and then macrocracks, the development of the cracks up to fracture point. A deduction was made to the effect that momentary overloading of the resonance type might be the cause of the fracture of machine parts from fatigue. A description is given of the experimental assembly; an original compensating contact apparatus is given for measuring and recording the deflections of the samples.

Yu. P. Grigor'ev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1757. Leith, W. C., Cavitation damage of metals, *Engng. J., Montreal* **42**, 3, 43–49, Mar. 1959.

Cavitation damage of metals can be observed on a magnetostriction-type of accelerated cavitation machine with a Fastax camera taking 8000 pictures per second.

A brief description of the mechanism of cavitation is given with some typical examples of cavitation damage to machine parts in service. The magnetostriction apparatus which is used to compare the relative resistance of materials to accelerated cavitation damage is described. Weight loss variations and correlated bubble formation patterns on test samples are shown for a range of vibration amplitude, temperature, and pressure.

Cavitation damage of metals in diesel cooling systems can be reduced by controlling the dominant liquid characteristic (temperature, pressure or wettability) at a stabilized cavitation level

while the increased metal resistance of stainless steel welded overlay on cast steel runners is more practical for hydraulic turbines. From author's summary

1758. Kachanov, L. M., On failure time under conditions of creep (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 26–31, Aug. 1958.

A creep rupture parameter Ψ is introduced such that $\Psi = 1$ corresponds to the virgin state, and $\Psi = 0$ to creep rupture. Hence $1 - \Psi$ measures the damage induced by the creep process. The law $d\Psi/dt = -A\,(\sigma/\Psi)^n$, $A > 0$, $n \geqslant 0$ being constants, is used to derive creep rupture time in a rod under uniaxial tension. This time is shorter than creep rupture time derived by Hoff, AMR **6** (1953), Rev. 2523, based exclusively on effect of decrease in rod diameter.

Analogous analysis is shown for thin tubes under internal pressure. Inhomogeneous states are discussed, and it is shown that the rupture condition $\Psi = \Psi_0 > 0$, which is more acceptable from physical viewpoint, can be replaced by the simpler one $\Psi = 0$ without appreciable error in the calculated creep rupture time. No experimental data are given. J. Hult, Sweden

1759. Manson, S. S., and Mendelson, A., Optimization of parametric constants for creep-rupture data by means of least squares, NASA Memo 3-10-59E, 34 pp., Mar. 1959.

An objective method utilizing least squares is presented for the determination of the optimum parametric constants for stress-rupture data. The method is applied to both constant-stress and isothermal data for the Larson-Miller, Manson-Haferd, and Dorn parameters. Several examples are treated in detail.

From authors' summary

Experimental Stress Analysis

(See also Revs. 1640, 1689, 1706, 1798)

1760. Dally, J. W., Riley, W. F., and Durelli, A. J., A photoelastic approach to transient stress problems employing low modulus materials, AFOSR TN 58-891 (Armour Research Found., Ill. Inst. Technol., Dept. Mech. Engng.; ASTIA AD 204 138), 32 pp., Dec. 1958.

The objective of the program was to develop a method, using photoelasticity and low-modulus materials, for studying dynamic stress distributions. A number of low-modulus materials were studied and Hysol 8705 (a urethane rubber compound) was selected as the most promising. A complete study of its mechanical and optical properties was made under static and dynamic loadings. It was established that Poisson's ratio ν is independent of rate of loading, the stress fringe value f_σ is independent of rate of loading for strain rates greater than eight (8) in./in./sec, and both the modulus of elasticity E and the strain fringe value f_ε were dependent on the rate of loading. The specific energy loss for the material was about 10% for the stress ranges associated with photoelastic determinations.

Experimental observations of photoelastic fringe patterns in a rectangular strut subjected to axial impact were made to illustrate the potential of the method. Three different end conditions were imposed on the unloaded end of the strut; (a) a free end normal to the axis; (b) a fixed end normal to the axis; and (c) a free end inclined 45° to the axis. For cases where the ends were normal to the axis it was found that the fringes followed the same law of reflection as the law for stresses given by elementary wave theory.

From authors' summary

1761. Aben, Hk. K., Application of the photoelastic method for investigations of buckled plates (in Russian), *Izv. Akad. Nauk EstSSR, Ser. Tekh. i Fiz.-Matem.* **6**, 1, 28–40, 1957; *Ref. Mekh.* no. 10, 1958, Rev. 11454.

Utilizing Maxwell's equations for the electromagnetic theory of light, an analysis is made of polarization-optical phenomena observed in the passing of light rays through plates, the stressed state of which (by their thickness) changes in regard to magnitude and direction. The experiment is described and the results analyzed. S. P. Shikhobalov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1762. Fel'dman, G. I., Solution of the three-dimensional problem of photoelasticity with the aid of a laminated (layered) model (in Russian), *Vestn. Mosk. In-ta* no. 1, 41–50, 1956; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11944.

For observations on the laminated model the optically active layer is irradiated in three directions: in the normal, and at angles of ±5° to the plane of the lamina. Author obtains six independent equations, permitting the determination of the six components of the stress tensor, by measuring the differences of the pseudo principal stresses and the parameters of the pseudo-isoclines and by carrying out a numerical integration. This method was utilized for the determination of the stressed state in a semispace under the action of a concentrated force. To do this, observations were carried out on a cube made of plexiglass of small optical activity, with sides of ~30 mm; a small plate of phenoplastic 1.7 mm thick was glued onto the plane of symmetry of the cube. The stress components along the vertical line were determined; this was 5 mm distant from the axis of the force's action. The divergence of the experimental data obtained in comparison with the theoretical did not exceed 15%. The field of isoclines obtained by the author did not agree with that resulting from Boussinesq's theoretical solution. E. I. Edel'shtein

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1763. Proshko, V. M., A theoretical investigation of the solution of a three-dimensional problem by the polarization-optical method (in Russian), *Trudi Mosk. In-ta Inzh. Zh.-d. Transp.* no. 91, 91–102, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11380.

Based on Maxwell's equations which describe the propagation of electromagnetic vibrations in a medium, differential relations are derived between the components of the tensor of the di-electric constant and the components of the light vector for the cases where the quasi-principal stresses in the plane of the front of a wave do not change or only slowly change their directions. The equations obtained with linear change of the angle of direction of the principal stresses by the distance along the beam lead to the equations given by Drucker and Mindlin [D. Drucker, R. Mindlin, *J. Appl. Phys.* **11**, p. 724, 1940]. The possibility is indicated, by using numerical solutions of the obtained equations, of finding, for different cases of the stressed state, the corresponding picture for the interference bands. No examples for this are given.

N. I. Prigorovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1764. Van Rooyen, G. T., and Loubser, R. S., Stress distribution and plastic deformation in a de-aerator dished end, *So. African Mech. Engr.* **8**, 6, 189–194, Jan. 1959.

Results of the recent testing of a de-aerator are described. By means of electrical resistance strain gages the stresses were measured on the toroidal section of the drumhead both on the inside and the outside. Results are compared with theoretical predictions. By means of the strain gages the yielding of the drumheads was also measured and the results discussed in terms of residual stress. From authors' summary

1765. Day, E. E., Performance of foil-type high-temperature strain gages up to 700°F, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 97–108, 1958.

Change in gage factor, zero shift, creep and hysteresis of Advance and Nichrome "V" foil gage, applied especially with RX-1 and AL-P1 cements, were studied up to 700 F and strain of 1000 microinches/inch. A great deal of attention was devoted to the behavior of gages on the initial heating and straining cycle.

Strain sensitivity tends to decrease with increase in temperature by an amount of 5 to 10% for all gages tested. Furthermore, deviation of strain sensitivity decreases with number of heating cycles to only a few per cent. Strain sensitivity is independent of the type or amount of strain. For the initial heating cycle up to 700 F, if gage has not previously been cured above 200 F, AL-P1 cement gives by far the most stable installation; for subsequent heating cycles after initial heating up to 700 F, RX-1 cement is the best. Zero shift is very pronounced throughout the first heating cycle, but tends to vary consistently to a maximum of about 200 microinches/inch for all gages tested. Initial zero shift is very large from the first heating cycle to the second, after which it is quite small. Creep was difficult to determine because it was superposed by zero shift. Hysteresis at 700 F was less than 2% of the range in every case.

Most of the difficulties can be eliminated when it is possible to cure the gage correctly and thoroughly before the testing cycle.

K. Fink, Germany

1766. Guerard, J. P., and Weissmann, G. F., Effect of hydrostatic pressure on SR-4 strain gages, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 151–156, 1958.

1767. Roots, O. T., An investigation of the two-dimensional stress condition in electric strain gauges (in Russian), *Trudi Tallinsk. Politekhn. In-ta* **A,** 107, 14 pp., 1957; *Ref. Zh. Mekh.* no. 2, 1958, Rev. 2506.

1768. Dally, J. W., Durelli, A. J., and Riley, W. F., A new method to "lock in" elastic effects for experimental stress analysis, ASME Ann. Meet., New York, N. Y., Dec. 1957, Pap. 57-A-71, 7 pp.

1769. Clark, E. C., Experimental verification of mathematically derived formulae, *Proc. Soc. Exp. Stress Anal.* **16,** 1, 57–68, 1958.

Paper describes some of the devices and procedures developed to apply the same kind of loadings to a simulated solid propeller blade as were assumed in the mathematical derivation. A standard screw-type universal testing machine was so modified that loadings including tension, torsion, and bending, singly or in combination, could be applied, and their effects measured for comparison with results predicted by formulas. From author's summary

Material Test Techniques

(See also Revs. 1725, 1749)

1770. Tsobkallo, S. O., and Vashchenko, Z. A., Comparison of the methods of static and of infrasonic loading for the purpose of determining the modulus of elasticity of laminar materials (in Russian), *Zavod. Lab.* **24,** 1, 68–70, 1958; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11847.

A description is furnished of two methods for determining the modulus of elasticity. In the first method the deflection is measured of the free end of a cantilever beam test sample, to which a static load has been applied. In the second method a measurement is made of the periodicity of the basic tone of the free vibrations of the cantilever beam test sample. It was shown that the second method offers possibilities of obtaining a more precise value for the modulus of elasticity, in virtue of a number of refinements in making the measurements, particularly because of the exclusion of the influence of elastic aftereffects which may appear at high temperatures. A. D. Pospelov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1771. Osipov, V. G., A method for mechanical tests by compression at high temperatures (in Russian), *Zavod. Lab.* **23,** 9, 1102–1104, 1957; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 6180.

1772. Kobrin, M. M., and Zaitsev, G. Z., Fatigue testing methods for large high-pitch spur gears, *Indust. Lab.* **24,** 2, 204–208, Mar. 1959. (Translation of *Zavod. Lab., USSR* **24,** 2, 193–198, Feb. 1958 by Instrument Society of America, Pittsburgh, Pa.)

1773. Kolosov, I. E., Form of specimens for fatigue testing of hardened steels, *Indust. Lab.* **24,** 1, 90–91, Feb. 1959. (Translation of *Zavod. Lab., SSSR* **24,** 1, 90–92, Jan. 1958 by Instrument Society of America, Pittsburgh, Pa.)

1774. Awatani, J., and Miyamoto, H., Fatigue tests of metals at ultrasonic frequency, *Bull. JSME* **2,** 5, 111–115, Feb. 1959.

A testing equipment and measurements are reported of the fatigue of metals under supersonic frequency. This equipment has an advantage over conventional fatigue machines that stress alternations up to 10^8 reversals can be made within an hour or so. At the resonant condition, metal samples are subjected to alternating stresses above the fatigue limit by means of a magnetostriction transducer through an exponential brass horn. By this method the fatigue properties of various metals were investigated. To avoid temperature rise of the samples, water cooling was necessary. Under insufficient cooling, it was not possible to obtain large motions and high strains, presumably due to the increase of internal damping in the samples. Even marks in the most strained part of sample such as might be made by a very light scratch with a knife edge had a considerable effect on the fatigue limit.

From authors' summary

1775. Gulyaev, V. N., and Ratner, A. V., A device for testing metals for prolonged stability in working media (in Russian), *Zavod. Lab.* **24,** 2, 226–228, 1958; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13622.

Device AP-2 for tests for fatigue is adapted for tests in conditions of high temperatures of tubular samples under internal pressure with tension and of solid samples in an active medium. The pressure is created by the evaporation of a condensate which is led into an ampoule heated in a separate oven. The ampoule is connected by the pipe conduit with the hollow part of the sample. The maximum magnitude of the pressure is 500 atm, the maximum temperature 700°. It should be noted that trials of the device gave positive results. V. S. Namestnikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1776. Schijve, J., Ultrasonic testing of compressor and turbine blades for fatigue cracks, *Aircr. Engng.* **31,** 360, 51–54, Feb. 1959.

Special probes were developed to test rotor blades for fatigue cracks. These probes utilize ultrasonic surface waves which are highly sensitive to fatigue cracks. The dimensions of the probes were kept small to make possible the testing of blades without the necessity of dismounting. The probes are built up from conventional commercial probes by attaching some small auxiliary equipment to them, which is very easy to manufacture. Searching blades with these probes is more reliable and less time-consuming than with previously available methods.

From author's summary

1777. Hendrickson, J. A., Wood, D. S., and Clark, D. S., Prediction of transition temperature in a notched bar impact test, *Trans. Amer. Soc. Metals* **51**, 629–642, 1959.

Concepts of the mechanism of the initiation of brittle fracture in mild steel were developed in a previous investigation employing notched tensile specimens subjected to rapid loading at different temperatures. These concepts are now applied to obtain a prediction of the transition temperature as determined in the standard Izod impact test. The predicted transition temperature is found to agree remarkably well with the experimental value.

From authors' summary

1778. Schniewind, A. P., An improved and semi-automatic method of conducting the standard hardness test for timber, *ASTM Bull.* no. 236, 57–59, Feb. 1959.

A semi-automatic method for conducting the standard hardness test for timber and the necessary modification of the standard test tool are described. This method gives a permanent record of the hardness values automatically, and can be used with any machine equipped with a load-deformation recorder. Several series of tests comparing the semi-automatic with the hand-operated method were made. One of these series showed a significant effect of operator on the results obtained by the manual method. In another series, where no such effect of the operator was present, there was no significant difference between the results obtained by the two methods. The semi-automatic method conforms exactly to the specifications of the test, and the results obtained are essentially independent of the human element.

From author's summary

1779. Palatnik, L. S., Fedorov, G. V., and Kosevich, V. M., The technique of measuring microhardness with thin films, *Indust. Lab.* **24**, 6, 857–859, June 1959. (Translation of *Zavod. Lab., SSSR* **24**, 6, 759–762, June 1958 by Instrument Society of America, Pittsburgh, Pa.)

1780. Vigdorovich, V. N., and Vel'pian, A. E., Procedure for obtaining true microhardness values by chemical removal of cold-hardened surface layers, *Indust. Lab.* **24**, 6, 860–862, June 1959. (Translation of *Zavod. Lab., SSSR* **24**, 6, 762–764, June 1958 by Instrument Society of America, Pittsburgh, Pa.)

1781. Ratner, A. V., and Guliaev, V. N., The investigation of turbine materials for resistance to scoring, *Indust. Lab.* **24**, 6, 869–873, June 1959. (Translation of *Zavod. Lab., SSSR* **24**, 6, 770–774, June 1958 by Instrument Society of America, Pittsburgh, Pa.)

1782. Yoshizawa, T., On ball indenters of tungsten carbide and of steel, *Bull. JSME* **2**, 5, 123–131, Feb. 1959.

Usually steel balls are used in Brinell hardness test and also in Rockwell hardness test. In Japan, tungsten carbide balls have been recently made in such sizes that they could be used as indenters in ordinary tests. In this research, these balls were used to measure the hardness of hard metals and their permanent deformation was observed to determine the maximum hardness values which could be measured with such balls without their permanent set; also the difference between hardness values of the same metals was measured with balls of different materials to prepare the new conversion table of hardness. This table was compared with one such ASTM table and the disagreement between them discussed.

From author's summary

1783. Yazawa, S., Unno, M., Yaguchi, G., and Sawano, I., Indentation hardness testing on copper, *J. Mech. Lab., Tokyo* **4**, 2, 57–59, 1958.

It is found in the case of copper that the relation between Mayer's hardness number and the diameter of impression, both in logarithmic scales, lies on several straight lines according to the extent of development of plastically deformed zone, as was the case with mild steel. By using this relation it is possible to determine the minimum dimension of the specimen for indentation hardness-testing.

From authors' summary

Properties of Engineering Materials

(See Revs. 1628, 1649, 1654, 1748, 1749, 1750, 1751, 1754, 1757, 1778, 1785)

Structures: Simple

(See also Revs. 1595, 1660, 1666, 1672, 1676, 1687, 1689, 1709, 1719, 1798, 2088)

Book—1784. Leontovich, V., Frames and arches—condensed solutions for structural analysis, New York, McGraw-Hill Book Co., Inc., 1959, xix + 472 pp. $20.

While the analysis and design of even an elementary statically indeterminate structure is likely to seem challenging and interesting to an engineering student, this task is somewhat less appealing to a practicing engineer. When such frames are frequently or evenly occasionally to be designed, any means of reducing the time and effort necessary to the accomplishment of this assignment has at least a certain economic value. Such means may be provided by this book if the task is the design of an elementary frame, and particularly the preliminary phases of the design process.

The book presents solutions for five shapes of single-span, single-tier, symmetrical frames and arches under various loading conditions. Each frame is treated for both pinned and fixed conditions at the base and for both uniform and nonuniform members. The solutions are presented as formulas for the redundant reactions, from which internal forces and moments at any section may be calculated by statics.

The form and content appear to be modeled after Kleinlogel's "Rahmenformeln" the first edition of which appeared in 1913, and which has been available in an American edition since 1952. While Leontovich presents solutions for frames with members having variable section, Kleinlogel gives solutions only for frames with uniform members. Kleinlogel, however, covers many more configurations, including unsymmetrical arrangement, tied frames and arches, and closed frames.

No new theory is presented. The solutions have been obtained by means of the usual flexural theory. When dealing with nonprismatic members, author introduces his "concept of elastic parameters." These, however, correspond closely to the well-known generalized stiffness and cross-stiffness coefficients for haunched and tapered members, some of which have been available for some time from other sources.

J. E. Goldberg, USA

1785. Gerard, G., Structural interplay: design and materials, *Aero/Space Engng.* **18**, 8, 37–42, Aug. 1959.

Elements involved in the materials-structures problem area are examined for compression and tension structures, and the nature of the interplay between design parameters and the mechanical properties of materials is reviewed. Thermal protection systems, which constitute a notable example of this interplay, are also discussed.

From author's summary

1786. Klein, B., Simultaneous calculation of influence coefficients and influence loads for arbitrary structures, *J. Aero/Space Sci.* **26**, 7, 451–452 (Readers' Forum), July 1959.

1787. Thadani, B. N., Solution of complex multi-storeyed structures, *Struct. Engr.* **37**, 6, 178–186, June 1959.

Author extends the iteration method of frame analysis to a complex structure where a column is continuous over more than one floor without lateral beams. The iteration formulas are derived for computing end moments due to both rotational and lateral displacement. A numerical example is worked out in detail. There are a couple of misprints in the section "The numerical procedure," where the notations for distribution factors u and v should be interchanged.

Reviewer considers the method useful in analyzing industrial or building frames subject to sidesway. Any structural engineer familiar with iteration process or moment distribution method should be able to master the method in a reasonably short time.

D. H. Cheng, USA

1788. Bolcskei, E., Shell-structures in foundations (in Hungarian), *Melyepitestudomanyi Szemle* **9**, 2, 72–73, Feb. 1959.

Author claims a new field of application for shell constructions and presents some invert shell forms which might well be applied in foundation design. The easy shaping of earth excavation makes the omission of extensive shoring and formwork possible and the saving in construction material is also well apparent. No suggestions for actual dimensioning or structural details are given; only the rough idea of application is shown for footings, strip foundations and for rafts. The question of bending and of stress concentrations at the boundaries is also not mentioned, although in this case—where the big concentrated loads transmitted by the columns must be spread on the soil by the invert shells—these must play a predominant role, and without deeper investigation the real economical value of the undeniably new idea can't be judged.

K. Szechy, Hungary

1789. Pappaert, J. M., Evolution of methods used for the calculation of prestressed concrete in compression and flexure: shells; Summary of papers presented at the 3rd Congress of the International Federation of Prestressing, Berlin, 1958 (in French), *Ann. Trav. Publ. Belgique* no. 4, 5–37, 1958/59.

1790. Gheorghiu, A., Conjugate systems and their utilization in the preparation of influence lines (in French), *Ann. Ponts Chaus., Paris* **128**, 6, 807–861, Nov.–Dec. 1958.

This work presents a significant generalization and unification of the various special techniques (such as conjugate beam, elastic weights, column analogy) found in structural mechanics whereby the calculation of deflections is replaced by statical analysis of a substitute structure called the conjugate structure.

Based upon the well-known analogy between statical and geometrical quantities, it is shown that one can associate with any elastic system submitted to given loads a conjugate system in which the loads correspond to the deformations of the first system, and that this relation is reciprocal. Examples for plane frameworks which deform in their plane and for plane frameworks which deform out of their plane are given.

E. H. Dill, USA

1791. Ormerod, A., Bending moments in pin-ended struts of variable section, *Civ. Engng., Lond.* **54**, 633, 333–334, Mar. 1959.

Expressions are developed which give the bending moments in pin-ended struts having one or more changes in section, and loaded with end couples and transverse loads. The expressions are put into a standardized form which can be extended readily to deal with any number of changes of section and a wide range of loads.

From author's summary

1792. Luoma, E. J., and Shand, E. B., Thermal shock resistance—a design parameter for ceramic radome walls, *Aero/Space Engng.* **18**, 6, 43–47, June 1959.

Experimental data on several candidate radome ceramics are reported for thermal stresses both perpendicular and parallel to the radome wall. Data are reported for Pyroceram Brand glass ceramic, high-purity alumina, and fused silica. The test medium was a molten salt bath. The desirability of a low thermal expansivity in this application is demonstrated.

From authors' summary

1793. Tsui, E. Y. W., Aseismic design of structures by rigidity criterion, *Proc. Amer. Soc. Civ. Engrs.* **85**, ST 2, (*J. Struct. Div.*) 81–106, Feb. 1959.

Structures: Composite

(See also Revs. 1706, 1723)

Book—1794. Jarocki, W., Designing waterways for bridges and culverts [Obliczanie otworow mostow i przepustow], Warszawa, Wydawnictwo Komunikacyjne, 1955, 302 pp.

This textbook is dedicated to the investigation and theoretical background for determination of the size of waterway for a bridge or the orifice of a culvert. Beginning with the outlines of hydrology and hydrometry, the book covers such problems as determination of the maximum flow and its probability, selection of the location for a bridge, river regulation for that purpose, computation of the size of orifices for large and small objects, taking in account water storage. The book is based on a wide experience in Russia, Poland and Western Europe.

S. Kolupaila, USA

1795. da Silveira, A. F., Thermic behavior of concrete dams (in Portuguese), Lab. Nac. Engen. Civ., Lisboa Mem. 125, 31 pp., 1958.

First part of paper discusses the influence of climatic factors, material properties and construction methods upon the thermic behavior of concrete dams.

Second part presents a practical example of temperature prediction in a dam for the cases of natural cooling and artificial cooling by cold water flowing through pipes embedded in the concrete.

D. Gh. Ionescu, Roumania

1796. Zvorykin, N. K., A bottom grid in water-collecting dams of mountain rivers (in Russian), *Trudi Gruz. N.-i. In-ta Gidrotekh. i Melior* no. 18/19, 323–332, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11148.

Results are described of the experimental investigations with grids of river dams. The experiments were carried out with grids of natural dimensions 0.6, 0.8 and 1m in length without any water-collecting galleries under the grid. The discharges of the models were 50 to 55 l/sec and less; silt-free water was used. Observations were carried out during the tests on the reduction in speed of the flow of the water through the grid along its length. The longitudinal profiles of the water above the grid at various rates of discharge have the form of distorted curves, almost parallel to each other. With increase of slope of the grid (the tests were carried out with $i = 0.0$ to 0.2) and of discharge passed through the grid, the curves approximated the linear. The divergence of the mean depth of water at the grid, equal to the half-sum of the side-depths from that determined by measurement at 11 points of the mid-depth, amounted to 8 to 10%; as the discharge and slope increased so did the percentage of divergence decrease, because of the approach of the level of the water to a straight line. It is noteworthy that the discharge coefficient of the grid when the clearances of the grid are made larger decreases to a significant degree, but fairly evenly, while with change of form in the bar section the above coefficient charges little and indeterminately.

The method and conditions of carrying out the tests are not described in sufficient detail (for instance, the width and height of the bars, the position of the grid in the trough, the methods employed for the measurement of the velocities of flow through the grid, etc.). The author proposes to carry out mechanical cleansing of the grid and of the water-collecting gallery from silt with the aid of a jet of water at 3 to 6 atm pressure; possible plans for delivery of water to the grid and gallery are discussed.

V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1797. Senkov, A. M., A new method of investigating the strength of hydrotechnical installations (in Russian), Trans. Sci.-Techn. Conf. on the Application of Electr. Energy in Agric., Leningrad, 1956, 83-94; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13326.

A description is furnished of the construction of a collecting dam consisting of a system of thin-walled ferroconcrete boxes, filled with soil and covered over the whole top by a concrete layer, ensuring a free flow of water over the dam. The results are also described of the field tests of the strength of a dam of this type which was constructed on the river Oredezh. The shear of the dam was determined by dynamometers, placed in the clearance between the console of the dam and the abutment. Observations disclosed that the commencement of shear in the dam took place at a value for the coefficient of friction considerably smaller than that determined for the given soil in laboratory conditions. At the same time a study was made of the nature of the filtration flow below the installation. The investigations, carried out in the laboratory of electric modelling of the Akad. Nauk USSR and also in natural conditions, showed that, frequently, the method of calculation applied according to Lane and Bly appears to be incorrect; reliable results are obtained by means of the hydromechanical calculations of the fragment method and of the EGDA.

V. V. Pinadzhyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1798. Harosy, T., Design of concrete tunnels (in Hungarian), *Magyar Tud. Akad., Musz. Tud. Öszt. Kozl.* **23**, 1/2, 39-62, 1958.

In the first part author derives an equation for the determination of the ratio of vertical and horizontal rock pressures around a circular hole, where the influence of lateral displacement and subgrade reaction is also considered. In the second part he derives a modification for the rock-pressure theory of Kommerell with the utilization of Protodiakonov's theory, based on the subsequent superposition of the compression of overlying layers resulting from the vertical displacement of a circular hole. Both his results must be regarded as mere approximations where the plastic behavior of rocks and linings is neglected, and, in addition to the defects of its principal assumptions, his results contain all those inherent to the above-mentioned original theories. Still, the way in which he deals with the problem puts some new light upon this rather intricate problem and means a step forward to its solution.

A. Szechy, Hungary

1799. Bailey, J. P., Effect of size of hatches on torsional strength and rigidity, *J. Ship. Res.* **2**, 4, 31-35, Mar. 1959.

The objective of the test described in this paper was to study the effect of hatch size on the torsional strength and rigidity of ships' hulls. Six plastic models, simulating the midship portion of a cargo ship, with various sizes and arrangements of hatches, were tested by subjecting to torsion and determining the resulting angle of twist, the approximate intensity and distribution of stress, and the torque required to produce fracture. Torsional rigidity was found to decrease generally with total width of hatches and with length of hatches. The torque to failure showed a greater variation between models than did the torque required to produce a given strain. The highest stress concentrations were at the hatch corners, and in every case the models failed at a hatch corner.

From author's summary

1800. Bonneau, E., Influence of kinetic heating on the vibratory response of the torsional mode of a wing (in French), *Rech. Aéro.* no. 61, 27-34, Nov.-Dec. 1957.

Author treats the loss in torsional stiffness caused by thermal stresses arising from aerodynamic heating. Solid wings of rectangular and double-wedge cross section are considered and results are obtained and compared with those given by Dryden and Duberg [AMR **10** (1957), Rev. 3747]. Paper includes an approximate analysis of the effect of the loss in torsional stiffness on the transient dynamic oscillations of an accelerated wing.

J. M. Hedgepeth, USA

1801. Hall, A. H., A preliminary analysis of the penalties associated with piercing a wing torsion box with a grid of holes, Nat. Aero. Establ., Canada, Lab. Rep. LR-236, 16 pp., Jan. 1959.

Paper analyzes stiffness of a wing torsion box with its skin pierced with holes for vertical take off fans. Results by Kuhn [NACA ARR 35, June 1942] are used to deal with the effect of the holes. Curves giving effect on design dive speed and structure weight for a hypothetical aircraft are given.

W. S. Hemp, England

1802. Santini, P., On the torsional rigidity of aircraft structures with multiple connection (in Italian), *Aerotecnica* **38**, 6, 323-326, Dec. 1958.

Extension of formulas for torsional rigidity of thin-walled structures is considered; for the case of multiply connected sections the exact expression for finite distance webs is derived. Also the case of infinitely thin, infinitely near webs is taken into consideration. A typical graph completes the work.

From author's summary

1803. Kiselev, V. F., Method for calculating the strength of a triangular wing taking into account the elastic seam (in Russian), Trudi Tsentr. Aerogidrodinam. In-ta no. 703, 43 pp., 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13270.

The calculation of the triangular wing merges with the calculation of a conical shell of small elongation. In the solution use is made of the basic equations for the stresses and deformations in the conical shell [see L. I. Balabukh, Tr. Tsentr. Aerogidrodinam. In-ta, no. 640, 1957]. The influence of the closed edge on the distribution of stresses in the wing is evaluated with the aid of the self-balanced system of internal stresses, presented in the form of a series, the terms of which are the products of two functions, changing along the contour of the section, and by the generatrix of the cone. The function for the change in the self-balanced system of stresses along the contour has to be selected in a suitable manner, while the functions for the change of these stresses by the span are determined from Euler's system of equations, obtained after varying the expression for the potential energy of the wing. An analogous solution is obtained for a triangular multi-walled wing, the walls being directed along the generatrix. In this problem superfluous unknown flows are introduced in the walls of the longerons, determinable from the system of canonical equations, derived from the method of forces. In analogy with the calculation formulas obtained for the wing of small span, formulas are also obtained for the calculation of a wing-swept caisson wing with stream-lined ribs. A pattern is indicated (based on an example) for the calculation of the bending of a triangular double-walled wing of rectangular section loaded by a force at its end.

I. L. Kats

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Machine Elements and Machine Design

(See also Revs. 1667, 1669, 1751, 1772, 2114)

Book—1804. Phelan, R. M., Fundamentals of mechanical design (Series in mechanical engineering), New York, McGraw-Hill Book Co., Inc., 1957, ix + 526 pp. $8.75.

This text combines kinematics, mechanisms, dynamics of machinery, and the design of machine elements all in one text, and as such is intended primarily for the nonmechanical engineering student. Engineering mechanics, strength of materials, properties of materials, and production processes are not covered separately, but only as they pertain specifically to the material under discussion. Despite the ambitious coverage, and due, by and large, to adroit selection of material, careful arrangement in logical sequence, and abundance of clear illustrations, the text is outstanding in comparison with the plethora of mechanical design texts in print. The chapter on the fundamentals of dimensional determination is particularly well organized, relating design choices to static and time-varying loading, combined stresses and failure criteria, including the effects of stress-concentration factors and fatigue. R. W. Mann, USA

Book—1805. Ham, C. W., Crane, E. J., and Rogers, W. L., Mechanics of machinery, 4th edition, New York, McGraw-Hill Book Co., Inc., 1958, xii + 509 pp. $8.50.

The text has two parts: The part on mechanism describes, mostly qualitatively, a wide variety of machine elements for transmitting and transforming motion. The second part, on kinematics and dynamics of machinery, discusses velocity, accelerations, static and inertia forces, the balancing of machinery and vibrations in shafts, and gyroscopic forces in a fairly traditional manner. The illustrations throughout the text are excellent, particularly the "skeleton" drawings of complex devices which illustrate the use of clear abstractions to identify body forces, accelerations, etc. Some of the applications chosen are timely, for example, rocket sleds, fluid accelerations in turbomachinery. A generous number of student problems is provided.

R. W. Mann, USA

1806. Ancker, C. J., Jr., and Goodier, J. N., Pitch and curvature corrections for helical springs; Theory of pitch and curvature corrections for the helical spring, Part I, Tension; Part II, Torsion, *J. Appl. Mech.* **25,** 4, 466–495, Dec. 1958.

A "thin-slice" method is used to analyze tension and torsion springs of round cross section. Method is applicable where bodies have same cross section throughout and same resultant forces and moments on each cross section. Three-variable boundary-value problem in elasticity is reduced to problem in two variables by this method. Consideration of symmetry leads to the general form of the displacements. In this three-section paper, the first two parts contain detailed treatment of tension and torsion springs, respectively. Third section includes estimates of computational error, and expressions for stresses, deflections, changes in curvature, etc. Stresses and deflections obtained are compared with conventional design formulas. Formulas from elementary theory are seen to be more in error for tension springs (10–20%) than for torsion springs (1–5%). A. G. Sharp, USA

1807. Bykov, V. A., Resistance of springs plastically compressed round their periphery (in Russian), Questions relating to the designing, manufacture and service of springs, Moscow-Leningrad, Mashgiz, 1956, 122–147; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13478.

Curves were drawn for the elastic-plastic resistance to tension, deflection and torsion of spring steel type 60C2. For deflection and torsion the actual stresses were determined on the basis of the nominal in relation with the A. Nadai formulas. Similar curves were drawn also for springs in compression. Here, in Nadai's formula, instead of the angle of torsion a value is introduced for the settlement of the spring, proportional to that angle. By means of tests on six springs made of steel type 60C2 satisfactory convergence was established between the actual value of the settlement and the calculated, the latter determined on the assumption of the existence of a state of "ideal plasticity." During tests for fatigue of a small number of plastically compressed springs of one type, an increase in the limit of fatigue was established (on the basis of (1 to 5) 10^6) of 30% by comparison with the original uncompressed springs. M. Ya. Shashin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1808. Livshits, P. Z., On the distribution of the contact pressure along the fitting length of a rotating disc (bushing) (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 66–73, Sept. 1958.

Stress distribution in case of a long rotating shaft with fitted disk of constant width is considered. Author took into account normal and shearing stresses and obtained the solution, when Poisson's ratio $\nu = 0.25$, in the form of infinite series. Unknown coefficients are found from the infinite system of linear algebraic equations. Auxiliary functions are tabulated and numerical examples are drawn in the diagrams. Z. Olesiak, Poland

Book—1809. Shigley, J. E., Kinematic analysis of mechanisms, New York, McGraw-Hill Book Co., Inc., 1959, x + 351 pp. $7.75.

Within the past three years several new undergraduate texts on the kinematics of mechanisms have been characterized by a modern approach to the subject. Among these are "Mechanisms and dynamics of machinery" by H. H. Mabie and F. W. Ocvirk (J. Wiley, 1957), "Kinematics" by V. M. Faires (McGraw-Hill, 1959), and the text by Professor Shigley being reviewed. This text contains most of the classical material on vectors, velocities, accelerations, gears, mechanisms trains, linkages and cams. In addition, however, a significant number of modern developments are presented in these categories: (a) Elements of complex-number representation of vectors; (b) the Euler-Savary equation; (c) involutometry of spur-gears, including nonstandard gears; (d) modern developments in linkages involving complex-number determination of velocities and accelerations, maxima and minima, and "atlas" methods; (e) a paragraph on advanced cam curves; (f) a chapter on the vectorial analysis of displacements, velocities and accelerations in space mechanisms; (g) a chapter on analog computing mechanisms; (h) a brief table of involute functions given in an appendix.

This emphasis on modern developments and the feeling of aliveness of the subject gained in studying this text is an impressive feature. The material on spur-gears is extensive and excellent and the material on cams, mechanisms trains and linkages is good. The separation of the chapters on velocity and acceleration from those on the geometry of motion and linkages would, it is believed, create a problem in the classroom; the treatment of the Euler-Savary equation is sketchy and not clear, and the chapter on space mechanisms probably not sufficiently developed to be meaningful in a first course.

The text is a definite advance, however, over the so-called "standard" work-out texts which have been used for so many years, and presents a creditable step in the modernization of the curriculum in this field. F. Freudenstein, USA

1810. Hall, A. S., Jr., A novel linkage design technique, *Mach. Design* **31,** 14, 144–151, July 1959.

In the analysis of mechanisms, the concept of the inflection circle and the use of the Euler-Savary equation, though long known overseas, have not been utilized in this country. They are now re-

ceiving recognition here. This article illustrates their application to linkage syntheses with several examples.

C. E. Balleisen, USA

1811. Rossner, W., Six-bar link drive to generate prescribed link curves (in German), *Maschinenbautechnik* **8**, 2, 105–106, Feb. 1959.

Paper considers the possibility of having an alternative design of six-bar pin-jointed linkages where a four-bar linkage found by conventional design for describing a specified link curve is found unsuitable for some reason or other.

B. M. Belgaumkar, India

1812. Luck, K., On the generation of link curves of four-bar linkages (in German), *Maschinenbautechnik* **8**, 2, 97–104, Feb. 1959.

In the design of link drives for specified motion it happens quite often that the dimensions of the design become unsuitable for practical reasons. In such cases one has to search for alternative kinematic chains which produce the same required motion but with altered dimensions. Paper treats the problem of generation of link curves of pin-jointed quadric chains by other linkages which allow the alteration of the dimension and location of base link, retaining the initial conditions of motion. Roberts' theorem has been used to give a reference chart of all four-bar link drives which can originate from a kinematic chain satisfying Grashof's condition. Using additional quadric chains derived from Roberts' theorem, the tracer points of which describe the same curve, five-bar two-crank chains have been developed. The cranks of these chains must rotate at equal angular velocities, which is achieved either by tie-bars, or gears, or chain drive. Reference is also made to recent Soviet literature on link transmission problems.

B. M. Belgaumkar, India

Fastening and Joining Methods

(See also Rev. 1751)

Book—1813. Mechanisms, couplings, driving-elements [Getriebe, Kupplungen, Antriebselemente], Braunschweig, Friedr. Vieweg & Sohn, 1957, 294 pp. 28.80 DM.

Book contains the fourteen papers and reports presented at the technical meeting "Getriebe elements" held at Essen in 1956 and the discussions which took place after their reading.

(A) Three papers are devoted to vibration problems: Ober-Ingeniur A. Eberhard of the Daimler-Benz A. G. examines the question of torsion vibrations occurring in an installation comprising two or more diesel motors connected by reduction gears to a common shaft. After a short review of the theoretical principles, the vibration conditions arising in diesel motors coupled to a shaft having six and more (to 20) cylinders are analyzed and the influence of some damping devices are discussed. Author shows that the conclusions deduced from this former study can be extended to the case of twin arrangements.

In a paper entitled "Vibration in ship transmission mechanisms," Dr. A. Cameron of the Mechanical Engineering Department, University of London, describes a process for the analysis of vibrations. A vibration graph is obtained and used in making a Fourier synthesis with the aid of an analyzer apparatus. The different vibration modes are, in this way, separated from each other and expressed in multiples of the shaft velocity. A process for analyzing harmonical vibrations is explained and the instruments necessary for the measurement are described. It is shown that self-vibration of journals, arising from the oil film, can occur. Combining the results obtained by a theoretical study of the question made by Hummel and Robertson, author shows that his own theoretical results are in good agreement with data deduced from an experimental installation.

Some schemes studied by the German air transport industry, about the year 1930, for the mechanical transmission of power from the engines to the propeller, are discussed by Prof. Dr. Ing. K. Lurenbaum in a paper "Vibration problems in long transmission shafts coupled to twin motors." The means of controlling bending and torsion vibration when the two motors, or one motor, are running are discussed. Results of the measurements of torsion vibrations made during the first trials are given.

(B) Lubrication: Two papers treat the problem of lubrication. The problem of boundary lubrication which occurs in machines, principally at the beginning or at the end of motion, or when foreign bodies are mixed with the lubricating oils, is discussed by Dr. Ing. Bartel, Institut für Erdölforschung, Hannover. The principal types of tooth damage in gears are analyzed and their prevention by the use of additives is shown. For correctly designed bearings, hydrodynamic lubrication generally occurs, but in the case of high pressures or high temperature, the use of well-adapted byproducts, capable of reacting with the metals, can give good results. A series of figures representing the damage produced on the surface of bearings tested with a laboratory machine are given; the influence of different oils and additives, the influences of velocity and time can be deduced for these results. For such tests the apparatus designed by the author and used in the Institute where he is working can resolve problems of friction and wear.

F. T. Barwell and J. A. Cole in a paper "Factors affecting the behavior of friction bearings" describe results of research work performed by Cole and Hughes in the Mechanical Engineering Research Laboratory, Glasgow. The method previously indicated by Vogelphol, using glass bearings, was followed, but, in this case, great care was taken to get very exactly constructed bearings. The journal (25-mm diam) was tried in different conditions of oil inlet, length, relative eccentricity, pressure and velocity. The lubricating oil could be brought to a fluorescent state by ultraviolet light and the illumination could be made permanent or instantaneous. Photos showing the oil film for the different examined conditions are reproduced and discussed.

(C) Gears: Five papers are devoted to gears; two deal with the problem of their strength calculation and two others with the problem of their fabrication and their measurement.

Prof. Dr. Ing. G. Niemann and Dr. Ing. H. Winter in a paper entitled "Strength calculation of spur gears" present the results of research work conducted at the Research Station for Gears and Machine Construction at the Technische Hochschule, Munich. Experimental tests and theoretical comparative examination have lead the authors to propose for the data concerning the position of the loading force, the considered footthickness. This formula contains coefficients which take into account the influence of the helix angle, the irregular load distribution, the dynamical situation and the form of the fillet. For the load capacity of tooth profile, the proposed formula supposes the load is acting on the lower point of contact and admits that the pressure is the principal criterion. The coefficients which appear take into account the irregular load distribution, dynamical situation, gear materials, and so on. Many values can be taken from charts and simplified methods for calculation are given.

In a paper "Zahnfussfestigkeit bei neuzeitlichen Getriebekonstructionen" B. W. Kelley, Staff Engineer, and R. Pedersen, Research Engineer, Research Department, Caterpillar Tractor Co., Peoria, Illinois, U.S.A., give a report on a series of photoelastic tests made on gears whose pressure angle amounts to 25° and 27°30′. The research was executed under the direction of Prof. Broghamer, Illinois University, who proposed in 1942 a modification of the well-known Lewis formula. Diagrams showing the position of maximum stress for different load positions are given. The theoretical Lewis method is conserved to a certain point in

order to get an equivalent trapezium profile even though this method does not necessarily give the maximum stress at the weak section. The addition proposed by Heywood for the increase of stress is conserved. The new equation proposed gives results which agree very well with those deduced from all the existing models.

"The measurement of big gears" is the subject treated by Diplom. Ing. F. Pohl of the W. Ferd. Klingelberg Sohne, Hückeswagen/Rhld. The paper concerns gears whose diameter is between 600 and 1000 mm. The three important types of error considered are pitch error, profile error and tooth-spiral error. The apparatus used for the measurement of these three characteristics is described; diagrams showing the results of measurement are presented.

Diplom. Ing. S. G. Klemming of the ASEA, Sweden, presents a paper on the shaving of gears. His aim is to give some results of practical experience in *shaving* gears of large size which, according to his experience, are now treated in this manner in the U.S.A. and England. Details are given on the tools, on machines and on working process. Author emphasizes the fact that the correct use of a *shaving* machine requires long experience, especially when large gears are to be treated.

The contribution of Obering. H. Strelow of the "Schopper and Faeser G.m.b.H. Minden," entitled "Relations between noise and processes of machine construction," deals with preventing the noise arising in gear running. The results of recent experiments on friction forces and of noise measurement are given. From these results it is concluded that, among other things, small involute profile errors, especially when they occur periodically, are a cause of noise. By means of statistical measurements giving the variation of the distance between axes of two rotating wheels, pressed against each other with a constant force, author deduces the involute profile errors which, depending on the cutting processes, are periodical errors or not. Such diagrams present the possibility of putting cutting processes in two classes. Silent gears are produced by processes giving nonperiodical profile errors. Typical diagrams representing the axes distance variation of gears cut with different processes are given; the influence of eccentricity on noise is shown. Author points out the improvements obtained by the use of helicoidal gears although more severe conditions are imposed for cutting and for housing. Attention is drawn to the necessity of using high sensitivity test instrument for checking the gears.

(D) Reduction mechanisms in air transport machinery: This subject is treated in two papers.

Prof. Dr. Ing. G. Madelung of the Technische Hochschule, Stuttgart, in his contribution "Does the designer of air transport machinery need reduction mechanisms today?" examines the consequences of the introduction of turbo engines in the propeller machinery of air transport apparatus; and he asks if the air transport technique will still use strong gear mechanisms of high quality.

To answer this question, author considers at first the part played by the gear mechanisms in the air transport machines during the past fifty years, analyzing the different evolutions which took place. The use of a critical value (power multiplied by the square of a rotation velocity) proposed by the author in 1921 shows that, with the introduction of gas turbines for air transport machinery, the problems which arise for the transmission gears are of the same order as those encountered for the reduction gears used with ship turbines.

In a paper "Mechanisms in airplanes" Diplom. Ing. H. von Thungen of the "Zahnrad fabrik Friedrichshafen," agreeing with the conclusion of Prof. Madelung, presents a general view of the mechanisms encountered in some modern airplane machinery (especially planet gears). A dozen types of airplanes are examined; the different solutions found in the power transmission from piston engines and turbine engines to propeller are shown; the mechanisms encountered in jet engines are analyzed. From this study author deduces that transmission gears will be needed as long as propeller engines are in use; it is stated that such mechanisms have not yet solved all the problems and that driving of the auxiliaries will still need gears and gear mechanisms.

Problems concerning air transport are also considered by Dr. Ing. W. Just of the "Deutsche Studien Gemeinschaft Hubschrauber e. V. Stuttgart-Flughafen" who treats many of the problems peculiar to the construction of helicopters. Five types of such flying machines are considered and their principal characteristics are analyzed and discussed regarding power transmission machinery, means of balancing the rotation moments, ways of joining the rotor blades to the rotor-shaft, blade dispositions, steering mechanisms, reduction gears, couplings between engines and propeller shaft.

(E) Special transmission mechanisms: Two contributions are devoted to such mechanisms.

Prof. Dr. Ing. K. Kollmann presents a "Contribution to the construction and calculation of free run couplings." The characteristics of the couplings with axial and radial forces are analyzed and it is shown that in the two cases, the optimum conditions are obtained when friction is reduced as much as possible between the force closing elements. The use of ball bearings is therefore indicated. The pressures calculated by the Hertz formula are discussed for different designs. The peculiarities of a chain transmission giving the possibility of changing gradually the velocity ratio is discussed by Dr. Ing. O. Dittrich of the P. I. V. Works Bad Homberg. The treated mechanism belongs to the category for which the radii of the driving and the driven element are simultaneously changed. Optimum running conditions are discussed and details are given, among others, on the chain design. Results of tests are reported; an arrangement using two chains separated by an axially movable plate permits the development of high pressures. At the end of the paper some figures concerning the capacity of the transmission and of its efficiency are given.

D. DeMeulemeester, Belgium

Rheology

(See also Revs. 1648, 1732, 1883, 1884, 1916)

1814. Symposium on non-Newtonian fluids in science and engineering, *Indust. Engng. Chem.* **51**, 7, 839–888, July 1959.

This symposium comprises 17 papers covering numerous aspects of non-Newtonian fluids, with particular emphasis on polymeric systems. When arranged by subjects the papers fall into 5 groups. The first group deals with the basic properties of fluid systems.. Working definitions are given for Newtonian and Bingham systems, pseudoplasticity, dilatancy, thixotropy, rheopexy, and viscoelasticity. One paper in this group gives a quantitative theory of thixotropy based on considering the disentanglement of molecules at high shear stress as a rate process. Reviewer believes that these papers will be of special value to readers not familiar with this field.

The second group of papers deals with viscoelasticity from both the experimental and theoretical points of view. Of particular interest is one reporting a study of the Weissenberg effect of solutions of polyisobutylene, in which the effects of experimental variables such as temperature, solvent, molecular weight, and viscosity on the normal stress of the solutions under shear were investigated. Another paper shows that viscoelasticity can be observed by stress-optical analysis. The propagation of transverse waves in fluid jets can also be used to detect viscoelasticity, for in viscoelastic fluids transverse waves show decay in tension or increasing wavelength as well as damping. The third group reports investigations of two systems. The first, vinyl resin plastisols, was studied by means of a cone and plate viscometer and characterized by the two constants of the power law relating

shearing stress to rate of shear. The second is the study of the flow of water suspensions of paper-making fibers. In this it was found that the flow consists of a central core of entangled fibers surrounded by an annulus of clear water.

The fourth group deals with three specific problems related to flow. The first is the fall of liquid drops through pseudoplastic fluids. In this it was found that the drag coefficient could be correlated with Reynolds number as calculated from the apparent viscosity. The second is a study of the onset of turbulence in non-Newtonian flow as related to the velocity profile at the entrance of a pipe. The third deals with heat transfer to turbulent non-Newtonian fluids. The analogy between turbulent heat and momentum transfer is extended to these fluids and experimental verification is reported.

The fifth and last group of papers deals with four problems of practical importance. The first two deal with the extrusion process. The first presents a mathematical analysis adapted to machine computation and the second deals with flow irregularities and their causes. The third deals with injection molding and shows that performance of a polymer can be directly related to its rheological properties. The last paper develops a correlation that permits calculation of power requirements for the agitation of non-Newtonian liquids in the laminar region.

Reviewer believes that this symposium will be a useful summary to those concerned with flow of non-Newtonian, especially polymeric, fluids. The inclusion of 185 literature references greatly enhances its usefulness. J. W. Givens, USA

1815. Epprecht, A. G., The real flow behavior of plastic substances (in German), *Schweiz. Arch.* **25**, 3, 82-87, Mar. 1959.

Author discusses viscometry of Bingham plastic solids, emphasizing rotational viscometers. J. L. Ericksen, USA

1816. Gurevich, M. I., and Pykhteev, G. N., Some methods for the solution of problems in the theory of streams of heavy liquid (in Russian), *Trudī Mosk. Tekhn. In-ta Rybn. Prom-sti* no. 8, 48-65, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12550.

An account is given of the works of Marchi [Enrico Marchi, *Ann. Mat. Pura Appl.* **35**, 327-341, 1953]. The Woronetz method is described [Constantin Woronetz, *C. R. Acad. Sci., Paris* **236**, 3, 271-273, 1953]. Marchi's solution of the problem using Woronetz's method is given. One case is calculated in detail which showed identical results with those obtained by the methods of Marchi and of Woronetz. This is followed by a brief exposition of the known solution by N. E. Kochin of the flow of a heavy liquid over a ledge; the very same problem is then solved by the Marchi and Woronetz methods. These approximate methods of solution of the precise problem gave a rough approximation compared with the exact solution of the linearized problem advanced by N. E. Kochin. The mean depth to ∞, obtained by the Marchi method agrees with the N. E. Kochin result. The Woronetz method yielded a less accurate result. N. N. Moiseev

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Translation, courtesy Ministry of Supply, England

1817. Abbasov, A. A., Approximate solution for the problem on the nonstationary motion of a viscous-plastic liquid in a horizontal tube (in Azerb.), *Dokladī Akad. Nauk AzerbSSR* **13**, 11, 1153-1158, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11208.

The problem, previously examined in connection with a round cylindrical tube [*Dokladi Akad. Nauk SSSR* **107**, 2, 249-251, 1956], is solved by the same approximate method, that is by the method of evaluating the averaged acceleration [N. A. Slezkin and S. M. Targ, *Dokladi Akad. Nauk SSSR* **54**, 3, 1946], for the case of a flow between two unbounded and immovable parallel planes. Numerical calculations are carried out with the formulas obtained and the results published in tabular form.

S. M. Targ

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1818. Sagomonyan, A. Ya, The penetration of a narrow wedge into a compressible liquid (in Russian), *Vestn. Mosk. In-ta Ser. Matem., Astron., Fiz., Khimii* no. 2, 13-18, 1956; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12251.

An investigation is carried out, in its linear setting, of the problem of the penetration at a constant velocity of a narrow wedge into a semispace filled with an ideal compressible liquid. By virtue of the automodel problem, that known method merges with the solution of some boundary problem in the theory of functions of a complex variable. The following are established, the distribution of pressures over the wedge, the force acting on the wedge, and so forth. It is shown that the magnitude of the force acting on the wedge in the case of an incompressible liquid is twice as small as the magnitude obtained by Wagner; the explanation being that Wagner, when finding the given force from the theorem of the quantity of motion, disregarded the quantity of motion carried away by the particles of the free surface, thus causing an increase in the result. S. S. Grigoryan

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Hydraulics

(See also Revs. 1620, 1720, 1757, 1794, 1816, 1902, 2021, 2066, 2067, 2082, 2084, 2098)

1819. Bondarenko, V. S., The forms of bodies of rotation constituted from small amounts of liquid (in Russian), *Trudī Leningrad Tekstil'n. In-ta* no. 9, 314-318, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12545.

A theoretical study is carried out on the forms of equilibrium of a liquid taking into account the forces of surface tension when the forces of gravity are balanced either by means of hydrostatic pressure or by the forces of friction between the liquid and the solid body and the forces of adhesion. An examination was made of a drop on a vertical filament resting in two liquids. By formulating the conditions for the static equilibrium of the liquid a differential equation is obtained, the integration of which in the most general terms possible for the boundary conditions gave the possibility of determining the equation for the surface of rotation

$$Z = aE(k, \varphi) + bF(k, \varphi)$$

where $F(k, \varphi)$, $E(k, \varphi)$ are elliptical integrals of the first and second order, a, b are constants. With $a > 0$ and $b > 0$ the surface appears as unduloidal, while with $a > 0$ and $b < 0$ it is nodoidal. The boundary forms of an unduloid appear to be a sphere and a catenoid. Special cases of surfaces are investigated: (1) a drop on a vertical filament, surrounded by a continuous homogeneous medium; (2) the complete wetting by the liquid of the surface of the filament when the meridian is represented by a cutting from the catenary line (the catenoid meridian). It is shown that the obtained equation for the surface of rotation can be utilized for the measurement of the edge angles on a three-phase boundary, starting from the dimensions of the photographic representation of the figure being studied for the equilibrium of the liquid. A curve is furnished which simplifies the use of this equation when handling this photograph.

Yu. F. Dityakii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1820. Petrikat, K., Model tests on weirs, bottom outlet gates, lock gates and harbour moles, MAN (Maschinenfabrik Augsburg-Nurnberg), Tech. Bull., 1959, 62 pp.

Author, the chief engineer of the Research Laboratory for Hydraulic Steel Structures at Gustavsburg, Germany, presents a brilliantly illustrated report on current research work. The major topics investigated are: configuration of river bed close to a weir, hydrodynamic forces on gates, model similitude with full-scale structure, investigation of vibration in weirs and gates, design of bottom outlets, efforts to reduce the power in hoisting gear, filling lock chambers through gates, wave action in harbor basins. Well-developed modern equipment is used for experiments in the laboratory.

Good pictures, many in full color, emphasize the arrangements and some results. Discussions are also interesting, e.g., inconsistency in similarity in a drag of a cylinder and a sphere tested in still air, still water and in flowing water due to the different separation point. Generally, this publication is a valuable contribution to modern hydraulic research, and the editors are to be praised for its high standard. S. Kolupaila, USA

1821. Schmidt, M., The perfect and imperfect discharge under weirs (in German), *Bautechnik* **34,** 8, 301–303, Aug. 1957.

1822. Gani, J., and Prabhu, N. U., Remarks on the dam with Poisson type inputs, *Austral. J. Appl. Sci.* **10,** 2, 113–122, June 1959.

The paper consists, basically, of two parts; (1) a review of the continuous dam model with simple Poisson inputs, capacity K, a steady release except when the dam is empty, and overflows recurring whenever the dam content exceeds K; and (2) a brief analysis of the dam with continuous inputs which are infinitely divisible distributions of the Poisson type. Both problems can be interpreted as queuing problems and formulated by using the Kolmogorov equation for the transition distribution function. The first problem is a special case of Takács's [*Acta. Math. Acad. Sci. Hung.* **6,** 101, 1955] integro-differential equation for analogous queuing problems associated with telephony. The Kolmogorov equation reduces to

$$\frac{\partial}{\partial t} F(z,t) - \frac{\partial}{\partial z} F(z,t) = -\lambda(F(z,t) - F(z-b,t))$$

where $F(z,t)$ is a cumulative distribution function

$$F(Z,t) = Pr\{Z(\tau - t) \leq z \,|\, Z(\tau) = z_0\}.$$

$Z(t)$ is the content of the dam, at time t, b is the incremental input and λ is the output rate. The solution of the infinite dam problem leads to a more direct stationary solution of the finite dam problem ($K < \infty$) which is equivalent to the solutions given by Moran [*Austral. J. Appl. Sci.* **6,** p. 117, 1955] and Gani [*Biometrika* **42,** p. 179, 1955]. The second treatment results in the Kolmogorov equation

$$\frac{\partial F}{\partial t} - \frac{\partial F}{\partial z} = -\int_0^\infty \lambda(u)\,\{F(z,t) - F(z-u,t)\}\,du;\ 0 \leq z \leq K.$$

A stationary solution for the infinite dam exists when the mean input per unit time is less than the mean outflow rate per unit time. Detailed results are promised at a later date.

Although the mathematical treatment is thorough and almost complete, there is no indication of the practicality of the formulations insofar as actual water-storage problems are concerned. For this the cited work by Moran and other works by the same author are required. (See Moran, P. A. P., *Austral. J. Appl. Sci.* **5,** p. 116, 1954 and *Quart. J. Matb.* **7,** p. 130, 1956.)

E. Koenigsberg, USA

1823. Konovalov, P. P., Graphs for the determination of opening dimensions in an artificial structure (in Russian), Avtomob. Dorogi no. 1, 25 pp., 1955; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11147.

When a roadway is crossed by small streams the culverts constructed for the discharge of the water may be furnished with the minimum openings permissible under TU conditions of construction. On the assumption that the volume of the total surface rainwater discharge is equal to the volume of the pond before the earth filling of the roadway, with a depth of water in the pond of 1 m, a graph expressed in coordinates is drawn

$$I_{mean} = \sqrt{i_1^2 + i_2^2}$$

(where i_1 is the slope of the water runway, while i_2 is the slope of the embankment, that is the transverse slope) and F/k (where F is the area of the basin, while k is a climatic coefficient) to give the different values for the coefficients of the absorbing capacity of the soil (varying from 0.2 to 1.2 mm/min). The points lying between the constructed curves and the coordinate axes determine the conditions where the artificial culverts can be built without hydraulic calculations and with the minimum permissible dimensions.

P. G. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1824. Binnie, A. M., and Kamel, M. Y. M., Experiments on the flow of water in a tube at high rates of swirl (in French and English), *Houille Blanche* **14,** 3, 348–360, May/June 1959.

The motion inside a single- and a double-ended swirl chamber was simulated by rotating the central part of a long horizontal Perspex tube and admitting water under gravity through numerous holes in this portion. Thus the swirling velocity at entrance could be measured, and it could be changed without altering the discharge. With various obstructions in the fixed parts of the tube, the flow pattern was examined by means of injected color. The reversed axial flow, which had been discovered in previous experiments on large nozzles, was again found. At higher swirls a regime occurred which consisted of three streams moving toward the orifice of the obstruction along the axis, close to the wall, and at about half radius, with two intermediate streams in the opposite direction. Numerical results are presented in dimensionless form.

From authors' summary

1825. McJones, R. W., and Caplan, M. L., Generalized solution for the problem of pipe flow with friction and heat addition, *ARS J.* **29,** 5, 366–368 (Tech. Notes), May 1959.

A generalized chart method is presented for the rapid solution of pipe flow problems involving compressible fluids, including the combined effects of friction and heat addition. A typical chart is shown for the case of subsonic air flow through a duct of unspecified but constant wall temperature. Similar charts can be constructed for other problems. From authors' summary

1826. Asaturyan, A. Sh., Edigarov, S. G., and Chernikin, V. I., Isothermal flow of viscous liquids in open rectangular channels (in Russian), *Trudi Mosk. Neft. In-ta* no. 20, 305–313, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12702.

The problem is investigated of the laminar flow of an incompressible viscous liquid in a sloping channel of rectangular section. For the purposes of calculation use is made of the approximate equations for the motion of a viscous liquid in which all the terms of inertia are discarded and also the terms containing the velocity components perpendicular to the axis of the channel; in this procedure it is at once possible to look upon dp/dx as equal to 0 in Eq. [4], which follows from [6]. In its present setting and in the boundary conditions adopted by the authors the problem

coincides completely with the problem on the flow of a viscous liquid in a rectangular tube, examined by Boussinesq [*J. Math. Pures Appl.* **13**, p. 377, 1868], and the authors' solution reproduces Boussinesq's results. The paper concludes with an investigation of the formula obtained for the input; this formula agrees with Boussinesq's formula. By means of numerical computations the above formula is compared with other calculation formulas on the subject.

S. M. Targ

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1827. Tholin, A. L., and Keifer, C. J., The hydrology of urban runoff, *Proc. Amer. Soc. Civ. Engrs.* **85,** *SA* 2 (*J. San. Engng. Div.*), 47–106, Mar. 1959.

In construction of storm sewers it is highly important to know the discharge required during the periods of largest rainfall. Many papers have been written, especially in Italy, for ascertaining, in a given network, the more dangerous duration of a rainfall, provided that the largest two-hour rainfall is less than double the largest one-hour rainfall.

This question is not raised in this paper, which studies the needed discharge for a sewer system (of Chicago) for a storm of three hours duration.

Paper considers eight steps. The first one is concerned with the typical layout of the drainage areas; the second step determines the hyetograph of a design storm; the third one is concerned with the evaluation of the abstractions from rainfall. Other steps are:

4th, The determination of runoff hydrograph at the lower end of the elemental strips;

5th, Routing of the mixed flow along the channel of the street gutter;

6th, Routing of the sewer supply hydrographs from roof and street inlets along typical headwater sewer lateral;

7th, Routing of lateral outflow hydrograph by a time-offset method along the sub-mains and main outlet sewers to the point of discharge of the sewer system;

8th, The production of a series of easy-to-use design charts.

G. Supino, Italy

1828. Cox, A. D., and Clayden, W. A., Cavitating flow about a wedge at incidence, *J. Fluid Mech.* **3,** 6, 615–637, Mar. 1958.

1829. Shashkov, A. G., Flow of a viscous liquid through a ball valve (in Russian), *Izv. Akad. Nauk BSSR Ser. Fiz.-tekhn. Nauk* no. 2, 29–36, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12705.

An account is given of the experimental investigation of the flow of transformer oil through an adjustable slot between the ball and the seating of a ball-valve. An empirical formula is obtained reflecting the experimentally found curve for the relation of the coefficient of input to Reynolds number.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1830. Vereshchagin, L. F., Semerchan, A. A., Filler, F. M., and Galaktionov, V. A., The significance of the receiver in a flow of a water jet of supersonic velocity (in Russian), *Zh. Tekh. Fiz.* **27,** 11, 2640–2646, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12578.

A theoretical calculation is developed to show the relation of the degree of smoothing out of the pressure pulsations in the receiver to its capacity when a pressure is created in the receiver by means of a hydraulic compressor of supersonic pressure. One set of calculations was made at constant volume for the receiver (1 liter) using five models of the compressor with piston rod diameters of from 22 to 38 mm with a mean pressure of 1500 to 3000 atm; the second set used one model of compressor (diameter of piston rod 38 mm) and receiver volume of from 1 to 10 liter with a maximum pressure of 2000 atm. Simplifications were introduced into the calculations: the velocity of flow through the nozzle was assumed to be constant for the nozzle's section; the velocity of motion of the piston rod was taken to be constant in the half-period of the force stroke (power stroke) as well as in the half-period of the suction stroke; the coefficient of the compressibility of water was taken to be, as a mean value, 0.035×10^{-3}. The experimental investigation of the influence of the capacity of the receiver on the degree of smoothing out of the pressure pulsations showed that the theoretical calculations, notwithstanding the assumptions simplifying them, give satisfactory agreement with the experimental data. The results obtained enable the jet of water of supersonic velocity to be viewed, when emerging from a receiver of 5–6 liter capacity, as well smoothed out as regards pressure impulses and, therefore, for velocity impulses.

M. K. Mel'nikova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Incompressible Flow

(See also Revs. 1597, 1814, 1878, 1887, 1900, 1902, 1911, 1917, 1944, 1952, 2005, 2021, 2065, 2096, 2098)

1831. Tirskii, G. A., An exact solution of the energy equation in a particular case of the motion of a viscous incompressible fluid, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22,** 4, 777–786, 1958. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author derives an exact solution in terms of Weierstrassian elliptic functions for the two-dimensional flow of an incompressible viscous fluid with a Prandtl number equal to unity and the flow running between two nonparallel plane walls. The solutions for the radial speed and temperature profile obtained in the Weierstrassian functions are transformed to the tabulated Jacobian functions; this makes it possible to present the solution in graphical form. The energy equation occurring in the problem has already been integrated numerically by Millsaps and Pohlhausen [*J. Aero. Sci.* **20,** no. 3, 1953; AMR **6** (1953), Rev. 3904], as the author observes. In addition to Prandtl number 1, the exact solution can also be presented for some other fully determined values of the Prandtl number. However the solutions are rather complex in these cases.

E. Niskanen, Finland

1832. Stelson, T. E., and Mavis, F. T., Virtual mass and acceleration in fluids, *Trans. Amer. Soc. Civ. Engrs.* **122,** 518–530, 1957.

Measurements of virtual mass of bodies oscillating in water are presented. Method consists of measuring the resonant frequency of a supporting beam. Values of the added mass agree well with calculations based on potential flow theory.

Authors discount measurements from other sources which show augmented added mass for a body accelerating unidirectionally. Reviewer feels this is done without adequate argument.

D. C. Collis, Australia

1833. Kromov, A. G., Averaging the parameters of a flow (in Russian), *Sb. Nauchn. Trudt Ivanovsk. Energ. In-ta* no. 7, 109–116, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12394.

The question is investigated of the transition from local to centered parameters of a flow of gas in a channel in passing from a three-dimensional to a single-dimensional scheme of flow (velocity, pressure, temperature). The importance is underlined of the known situation that the order of centering of each parameter must have its origin in the structure of the equations for the flow, and cannot be accepted as arbitrary. Expressions are derived for

the centered parameters in the equations of continuity, quantity of motion and energy.

N. A. Kartvelishvili

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1834. Mikhalev, S. V., Investigation of a flow in a two-dimensional jet with a nozzle (in Russian), *Trudi Mosk. Aviats. In-ta* no. 97, 43–86, 1958; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12441.

The flow in a plane tapering jet with an ejector is investigated, both theoretically and experimentally. A model of the jet is examined; the section of the jet coincides with that of an ejector at the inlet into the mixing chamber. The solid walls of the ejector are replaced by combinations of punctate vortices, placed at infinitely close distances to each other. The geometrical location of the vortices correspond to the walls of the ejector. The intensivity of the punctate vortices and their general circulation are so selected that observations are possible on the basic physical features of the working ejector (the presence and the location of the critical points, correspondence of the velocity profiles within the ejector with the experimental profiles, and so forth). The basic calculation equations are obtained by adding up two flows: the flow of the turbulent submerged stream from the jet and the flow in the field of the system of vortices, which were substituted for the solid walls of the ejector. The analysis proceeds with disregard for the dissipation forces (viscosity and heat conductivity). It is shown by calculation that the auxiliary reactive force of the pull of the jet with the ejector has a positive sign when the ejector is tapering and a negative one when the ejector is widening. In the case of an ejector with a cylindrical mixing chamber the additional force of the pull is equal to zero. However, experiments on this point demonstrated that the cylindrical ejector actually gave a small additional force of the pull. This divergence, the author explains, was due to the presence of an undertow force. An investigation was made of the effect of the length of mixing chamber of the ejector on the reactive force of the pull of the jet when the inlet section was constant, as also the angle of slope of the walls of the chamber to the axis of the ejector. It was shown that, within the limits of 30 to 80 calibers, the reactive pull increases with increase in length of the mixing chamber. This result was confirmed by experiment (the calibers were determined by relation to the section of the tapering jet). A field of axial velocities inside the ejector's mixing chamber was drawn up. The calculated curves of the velocities agreed satisfactorily with the experimental. Appreciable divergence was only observed near the walls of the mixing chamber. The static pressures along the length of the mixing chamber, determined both by calculation and experiment, were found to be in good agreement.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1835. Shapiro, Ya. G., Experimental investigation of a liquid ejector (in Russian), *Trudi Mosk. Aviats. In-ta* no. 97, 191–236, 1958; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12633.

Results are furnished of an experimental investigation of an axially symmetrical water-ejector with a cylindrically shaped mixing chamber, the relative lengths of which were equal to 20 calibers. The ejector was tested with four interchangeable narrowing nozzles for a highly pressurized liquid with different sectional areas for the outlet. The active liquid entered the mixing chamber through a central nozzle. There was no outlet diffusor. In the tests the characteristics of the ejector's work were recorded, the field of velocities, the pressures and the pulsation velocities were observed in the various sections of the mixing chamber. It was explained that the process of the mixing of the streams in the water ejector presented a complex phenomenon, accompanied by the formation of velocity profiles and of pressure with turbulent exchange of impulses between the particles. The presence of velocity gradients leads to the production of considerable pulsations of velocities in each point in the mixing zone, resulting in internal losses of energy and friction losses on the wall of the mixing chamber. The measurement of such a type of velocity field with the aid of a Pitot tube results in significant errors which become larger with increase in the pulsation component of the velocity. The maximum velocity pulsation is observed in the initial portion of the ejector's mixing chamber. It was shown that pressure evens out along the section at a distance of 3.5 to 4.0 calibers from the beginning of the mixing chamber, and the velocities at a distance of 7 calibers. It is noted that in the initial portion of the mixing chamber a fall of pressure takes place between the streams, the size of which attains 7% of the velocity pressure of the active liquid and depending on the parameters of the ejector. It was shown that the losses on account of friction on the wall of the mixing chamber of the ejector are two to three times greater than the calculated values of the losses, determined by the mean velocity of the mixture. The author proposes an empirical formula for the determination of losses due to friction by means of the conditioned "velocity of friction." (The "velocity of friction" is defined as a velocity at which the losses due to friction in a steady turbulent flow are equal to the losses due to friction in the mixing chamber of the ejector.) Energy losses due to the mixing of streams in the ejector attain 50% and friction losses 10%. The author determines the efficiency (k.p.d.) of the ejector as the relation of the energy acquired by the passive liquid to the energy released by the working liquid. It is explained that the efficiency (k.p.d.) of the ejector depends essentially on the relation of V, the velocity of the passive liquid to the active V. The maximum efficiency (k.p.d.) of the ejector was observed with $V = 0.2 - 0.3$ over a wide range of parameters for the ejector. Some suggestions are made for the calculations of an optimum ejector.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1836. Pavlikhina, M. A., and Smirnov, L. P., Turbulent wake in flow past vibrating cylinders (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 124–127, Aug. 1958.

Paper summarizes a series of experiments on the frequency of vortex separation in the wake of a stationary cylinder and cylinder in forced vibration in a parallel stream.

With the stationary cylinder the frequency of vortex separation $(1/s)$ in a range of Reynolds numbers from 10^3 up to 3.10^5 is $n = 0.18\ v/D$ (v flow velocity, D diameter of cylinder).

With the elastically supported cylinder self-excited vibrations may occur on coincidence of vortex frequency and natural frequency of the cylinder. This may be described as a sort of resonance.

The vortex frequency being to a considerable extent dependent on cylinder motion, zones of influence ("control") appear where the vortex frequency adjusts itself to cylinder frequency, thus widening the range of possible self-excited vibrations.

The results, being of a qualitative character, still have great practical value.

K. Julis, Czechoslovakia

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 1597, 1800, 1830, 1867, 1868, 1869, 1873, 1886, 1888, 1889, 1891, 1919, 1920, 1935, 1950, 1951, 1957, 2011, 2020, 2024, 2025, 2028, 2065, 2114)

Book—1837. Cambel, A. B., and Jennings, B. H., Gas dynamics, New York, McGraw-Hill Book Co., Inc., 1958, xiii + 415 pp. $12.

This volume is an important contribution to the textbook litera-

ture on gas dynamics. The authors have covered a remarkably wide range of fundamental concepts and yet have succeeded in maintaining rigor and conciseness. Some sacrifice of elegance in presentation has had to be made but is understandable in a textbook written for a first course. The authors are unusually articulate and the text is unusually free from ambiguities and misleading conceptions.

Aside from its value as a college textbook the book warrants the serious attention of mechanical and aeronautical engineers who are interested in a comprehensive knowledge of the fundamentals of gas dynamics. J. F. Lee, USA

1838. Lidov, M. L., On limiting solutions near a singular point, *Soviet Phys.-Doklady* **3,** 3, 514-517, Jan. 1959. (Translation of *Dokladi Nauk SSSR (N. S.)* **120,** 6, 1224-1227, May-June 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

This mathematical paper deals with the behavior near the singular point at the center when a gas experiences a small perturbation from a "self-modeling motion," i.e., from a "progressing wave," in the terminology of AMR **1**, Rev. 1661. An example of this kind of perturbation occurs when a strong explosion advances into a medium in which the undisturbed density is not quite uniform.

D. C. Pack, Scotland

1839. Deissler, R. G., Weiland, W. F., and Lowdermilk, W. H., Analytical and experimental investigation of temperature recovery factors for fully developed flow of air in a tube, NACA TN 4376, 35 pp., Sept. 1958.

An analysis was made for determining temperature recovery factors effective on the walls of a tube for the case of fully developed flow in an insulated tube. In the analysis, the temperature distribution in the radial direction is first determined from the energy equation; eddy diffusivities for momentum and heat transfer are introduced. Bulk temperature is defined for constant specific heat. The effect of radial variation of properties is then neglected. Dimensionless quantities are introduced and the analysis carried to completion.

Recovery factors were obtained experimentally for a range of Reynolds numbers from 630 to 30,000. Additional unpublished data for Reynolds numbers up to 650,000 are presented. The estimated maximum possible error in calculating recovery factors is ±2% above Reynolds number of 16,000, ±6% from 4000 to 16,000.

Data is presented in nondimensional form in a number of graphs at the conclusion of the article.

Reviewer believes this to be a useful and effective paper.

E. G. Allen, USA

1840. Chiccine, B. G., and Abdalla, K. L., Experimental investigation of expanded duct sections and screens for reducing flow distortions at subsonic flows, NASA Memo 1-9-59E, 27 pp., May 1959.

Parameters investigated were expansion angle and length, area ratio, location of expanded section relative to engine face, and use of screens over a simulated engine-face Mach number range from 0.19 to 0.67. A 15° expansion half angle appeared optimum for reducing both radial and circumferential distortions while still maintaining high total-pressure recovery. Increased length and area of the expanded sections also reduced distortion. Screen solidities up to 22.2 reduced distortion with improved total-pressure recovery over a comparable constant-area configuration.

From authors' summary

1841. Mikheev, V. P., The transportation of gas with consideration for its cooling (in Russian), *Sb. Nauchn. Trudi Kuibyshevsk. Industr. In-ta* no. 7, 99-103, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12395.

The fact is noted that in engineering practice when designing and working compressor stations and the main pipe-conduit systems for the conveyance of gas the flow is ordinarily taken to be isothermal, that is to say, the influence is not taken into account of the initial temperature of the gas (at the entrance to the mains) on the hydraulic loss of pressure in the pipe conduit and its through-put capacity. Together with the above, approximate correlations are deduced for the non-isothermic motion of the gas in pipelines of great length. An approximate formula for the determination of the temperature of the gas at an arbitrary point of the extended pipeline is given on the assumption that the cooling of the gas is isobaric, the formula originating from the equation for heat emission and thermal balance and taking the form of

$$t = t_0 + (t_1 - t_0)\exp\left(-\frac{l}{V_0 C_p R}\right) \qquad [1]$$

where t_0 is the temperature of the medium surrounding the medium (e.g. the soil); l is the distance between the given sections of the pipeline and the compression station; V_0 is the consumption of gas, expressed in terms of normal conditions; C_p is the thermal capacity of the gas at constant pressure; R is the thermal resistance to heat exchange from the gas to the surrounding medium, determinable, similarly to the determination of the thermal resistance of an uninsulated pipe, by means of an approximate formula, adopted in thermal calculations of heat tubes in the form of

$$R = \frac{1}{2\pi\lambda_{gr}}\log_e\frac{4b}{D_E}\ \frac{\text{n.m. hr. degree}^\circ}{\text{k cal}} \qquad [2]$$

where λ_{gr} is the coefficient of heat conductivity of the soil, b is the depth at which the pipeline is laid in the soil (the distance from the surface of the soil to the tube's axis); D_E is the external diameter of the pipeline. It is claimed that calculations according to formula [1] with consideration for [2] agree more closely with the existing experimental data than do the calculations according to the known formula by V. G. Shuknov [Petroleum oil conduits and their application in the petroleum industry, Moscow, 1895], as the latter does not take into account the depth at which the pipeline is laid and the heat conductivity of the soil. The author obtained, with the help of Eq. [1], an approximate relation for the determination of pressure P in an arbitrary point of the main pipeline in the form given below; this was effected by the integration of d'Arcy's differential equation while taking into account changes of velocity of the gas and of its specific gravity in relation to changes of pressure and temperature:

$$P = \sqrt{P_1^2 - 2aV_0^2\frac{T_0}{273}\,l\left[1 + \frac{V_0 C_p R}{L}\,\frac{t_1 - t_0}{273}\left(1 - e^{-\frac{l}{V_0 C_p R}}\right)\right]}\ \text{atm} \qquad [3]$$

where P_1 is the pressure at the entrance to the mains; T_0 is the temperature of the medium surrounding the pipeline in degrees (absolute scale); the value of a is determined by the relation

$$a = 0.661 \times 10^{-3}\lambda\frac{\gamma_0}{D^5}$$

where λ is the coefficient of local resistance; γ_0 is the specific gravity of the gas in normal atmospheric conditions; D is the internal diameter of the pipeline. It is shown that this relation should be utilized when

$$\frac{V_0(t_1 - t_0)}{L} > 10 \text{ and } \frac{2aV_0^2 L}{P_1^2} > 0.8$$

where L is the full length of the main pipe conduit. Examples are furnished of the influence of a non-isothermal flow of gas in the main pipe conduit (length 10.50 to 100 km) on the pressure loss in

the system in relation to the volume of gas handled (25,000 hm^3/hr and 65,000 hm^3/hr) and to the diameter of the pipeline (250 and 300 mm, respectively) at different initial thermodynamic parameters ($t_1 = 40°$ and $P_1 = 50$ atm; $t_1 = 80°$ and $P_1 = 40$ and 50 atm). When carrying out the calculations it was decided that $t_0 = 0°$, C_p = 0.40 k cal/hm^3 degrees, $h = 1.5$ m, $\lambda_{\text{эф}} = 1.0$ k cal/m hr/degree, $\gamma_0 = 1.0$ hΓ/hm^3. However it is not indicated for which of the coefficients of pressure these data were obtained. It was shown that the use of the formulas for isothermic flow for the determination of the magnitude of the pressure loss led to the lowering of the actual figure for the loss of pressure by 10–16% and more. It was recorded that a specially large error was noticeable in the case of short lengths of the mains and at small end pressures. There is a large number of mistakes (misprints) in the formulas.

G. E. Khudyakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1842. Johnston, P. J., Transonic aerodynamic characteristics of two wedge airfoil sections, including unsteady flow studies, NASA Memo 4-30-59L, 45 pp., June 1959.

A wind-tunnel investigation has been conducted to determine the two-dimensional aerodynamic characteristics of a single 20-percent-thick wedge-airfoil section in the Mach number range of 0.70 to 1.25. The results are compared with those of a diamond profile having the same leading-edge included angle. Pulsating pressure measurements are presented for the single wedge for leading-edge radii of 0, 0.5, and 1 percent of the chord. The single wedge produced normal-force curve slopes significantly higher than those previously measured on conventional thin airfoils.

From author's summary

1843. Spreiter, J. R., and Alksne, Alberta Y., Aerodynamics of wings and bodies at Mach number one, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 827–835.

In NACA TN 3970 [AMR **11** (1958), Rev. 537] the authors presented a new, simple, and very successful approximate theory for computing transonic flows. In this paper the theory is used to calculate pressure distributions on the following non-lifting symmetric bodies: (1) wedge airfoils, (2) airfoils whose shapes are given by $y \sim (x/c) - (x/c)^n$ where $n = 2$ and 6.05, (3) a cusped trailing edge airfoil, (4) cone-cylinders, (5) a body of revolution whose shape is given by $r \sim (x/l) - (x/l)^2$, (6) thin elliptic cone-cylinders. For thin bodies at small angle-of-attack at $M = 1$, it is shown that the lift distribution is given correctly by linear slender-body theory whereas the actual pressure distribution with thickness effects can be obtained by use of the authors' theory.

The results are compared with more exact (and far more laborious) theories and with experiment. The agreement is again very good, further justifying the use of the theory for predictive purposes.

A. E. Bryson, Jr., USA

1844. Chushkin, P. I., The flow past ellipses and ellipsoids by a transonic flow of gas (in Russian), *Vychisl. Matematika* no. 12, 20–24, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12266.

The solution of nonlinear equations is approximately merged with the problem of the integration of a system of ordinary differential equations. The calculations carried out by the author on high-speed electronic calculating machines show the rapid convergence of the adopted method; this permits a practical delimitation of work by means of a system with a small number of equations. Comparisons are given with results obtained with other theories.

I. M. Yur'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1845. Eckhaus, W., and De Jager, E. M., Linearized theory of lifting sweptback wings at sonic speed (in English), Nat. Lucht-Lab., Amsterdam TR F .206, 21 pp., Sept. 1957. Reports and Transactions **XXI**).

Linearized theory is presented for determination of the load distribution either at sonic speed or for low-aspect-ratio wings. With the only restriction of symmetry of the wing with respect to flow direction the method is valid also for any given camber and twist of the wing. Some reports, cited by the author, have also treated the case of slender-body theory with swept trailing edge, which condition leads to much more complicated determination, as in Jones' theory for delta wings. Whereas K. W. Mangler [AMR **9** (1956), Rev. 1879] related the downwash to the load distribution, in the present paper the downwash is related to the vorticity component in streamwise direction. It is said that by aid of this method some knowledge about the behavior of the vorticity in the wake is obtained, especially near the kink of the trailing edge. After having finished this report author received a paper of E. Truckenbrodt [AMR **11** (1948), Rev. 241] where the same problem is treated, but methods and object in view are very different, so that reviewer believes that the one paper does not supersede the other. Theory is applied to a sweptback wing without taper and to the same wing with taper. Comparisons with Mangler's method are made.

F. W. Keune, Germany

1846. Carafoli, E., and Khorovits, Beatris, Supersonic flow about of an angular wing with terminal disks (in Russian), *Zb. Prikl. Mekh., Akad. RNR* **1**, 7–33, 1956; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12279.

The basic results of this work have already been published in previous works of the authors [*Comm. Acad.* RPR **3**, 11/12, 395–404, 1953; **4**, 5/6, 271–283, 1954]. Using the linearized setting, an investigation is made of the supersonic flow of gas about a triangular wing on which is placed a thin disk having the form of two triangles raised perpendicularly to the wing on two sides. The wing can be thin or "thick," its edges transonic or supersonic, the disk's edges transonic. It is assumed that the field of velocities is conical. By applying the method of conforming reflections and the method of hydrodynamic analogy, worked out by Carafoli, authors find, in the closed form, formulas for the components of the velocity of disturbance essential for the calculation of the pressure in cases where the local angles of attack of the wing and disk are constant on the individual portions. These formulas include a series of constants, for whose determination conditions are laid down. In the nature of a supplement to the formulas obtained, authors examine a plane rectangular wing with terminal disks (as a boundary case of a triangular wing); for this case formulas were obtained, expressed in elementary functions, for the resistance coefficients, the lift and the rolling moment. Analogous formulas embodying elliptical functions were obtained for a wing consisting of four cruciformly orientated planes with symmetrical changes of the angle of attack along the span.

B. M. Bulakh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1847. Portnov, I. G., Theory and calculations for stationary regimes of the work of a supersonic gas ejector (in Russian), *Trudi Vses. N.-i. In-ta Prirodn. Gazov* no. 2(10), 130–162, 1958; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12442.

An exposition is given of the calculation procedure for stationary regimes of the work of a supersonic gas ejector, applicable in conditions where the counterpressure beyond the diffusor is the result of the interaction of all the elements in the gas-dynamic system, in which, apart from the ejector, the gas wells, the gas pipe-conduits and the gas gathering collectors participate. The basic calculation formula equations are derived while making the

customarily accepted assumptions regarding the cylindricity of the mixing chamber, the absence of heat exchange through the walls of the ejector the complete mixing of the gases at the outlet of the mixing chamber, and so forth. In addition, a fundamental assumption is made regarding the presence of such a section in the ejector's mixing chamber (up to which point no mixing of the gases in the mixture takes place) in which the static pressures of the low-pressure and of the high pressure gases are equal and constant on that section (the section of equal pressure). The author asserts that the section of equal pressure actually exists, if a selection is made in corresponding fashion of the profile of the jet of the active gas. This assertion, taking the strict view, appears to be incorrect when the gases are mixed in an ejector with a cylindrical mixing chamber. The hypothesis on the existence of sections of equal pressure was first enunciated in the works of M. D. Millionshchikov and G. M. Ribinkov, but no reference to this is traceable in the present article. A number of works are also known in which it was demonstrated that the use of the hypothesis of the existence of sections of equal pressures, in the determined conditions, led to a significant divergence between the calculation data and the experimental results. Some examples are given of calculations for ejectors made by the method proposed by the author. Some ideas are put forward for the consideration of the influence of friction against the wall of the mixing chamber on the characteristics of the work of the gas ejector. Comparisons are made of the calculation results with those obtained by experiment.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1848. Poluboyarinov, A. K., Solution of equations for the axisymmetrical supersonic motion of a gas, linearized relative to the flow from the gas source (in Russian), *Vestn. Leningrad In-ta* no. 13, 102–112, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 10927.

The equations of an axisymmetrical vortex less supersonic motion of a gas are linearized relative to the flow from a three-dimensional gas source. Then the solution is found in final form of a single linear differential equation of a hyperbolic type. By approximating the coefficients, it is possible to bring together, approximately, this equation and the linearized equation for the axisymmetrical motion of the gas. However such approximations, it is shown, are only possible for regions of flow not containing axes of symmetry. In such a case the solution of boundary problems (the problems of Gurs, Koshi, the flow about a hard wall) is best obtained either with quadratic solutions or the integration of an ordinary differential equation of the second order. For regions containing an axis of symmetry the solution of the linearized equation is sought with the aid of series. The author holds the view that the proposed method can be adopted in calculations for the supersonic flow of gas in annular and round channels with variable transverse sectional areas.

P. I. Cheshkii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1849. Hoenig, S. A., Use of a catalytic probe for detection of dissociated non-equilibrium states in hypersonic flow, *ARS J.* **29**, 5, 361–363 (Tech. Notes), May 1959.

It is shown that a wheatstone bridge with one catalytic and one noncatalytic arm can be used as a sensitive detector for dissociation in hypersonic flow.

From author's summary

1850. Creager, M. O., Surface pressure distribution at hypersonic speeds for blunt delta wings at angle of attack, NASA Memo 5–12–59A, 15 pp., May 1959.

Surface pressures were measured on a blunt 60° delta wing at angles of attack from −10° to +10° for a Mach number of 5.7 and a Reynolds number per inch of 20,000. These surface pressures and pressures reported elsewhere for similar test bodies at Mach numbers of 11.5 in air and 13.3 in helium are compared with those predicted by a method developed previously for two-dimensional flow.

From author's summary

1851. Chernyi, G. G., Influence of slight blunting of the leading edge of a body on hypersonic flow around it (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 54–66, Apr. 1958.

Manufacturing and maintainance of ideally sharp leading edges and noses is practically impossible, hence a discrepancy arises between the theory established for sharp edges and actual flow around slightly blunted edges, where a detached shock is formed with a subsonic adjacent region. Semi-empirical method is worked out showing that the pressure distribution in the vicinity of the leading edge is the same for different thin profiles having the same shape of bluntness on their edges or noses. The data for a flat plate can be used for all of them. For moderate supersonic speed the pressure on the remaining body is practically unaffected by the nose bluntness, and can be computed from a sharp-edge theory. For high supersonic speed a slight blunting of the edge can considerably alter the pattern of flow over a large region. The method consists in replacing blunted edge by action of concentrated forces on the flow; it is applied to blunted wedge where it shows doubling of the drag computed by classic theory, and to cones, where the drag of a blunted cone may become smaller than that of a sharp one.

P. Bielkowicz, USA

1852. Shikin, I. S., On exact solutions of the equations of one-dimensional gas dynamics with shock and detonation waves, *Soviet Phys.-Doklady* **3**, 5, 915–917, May 1959. (Translation of *Doklady Akad. Nauk SSSR (N. S.)* **122**, 1, 33–36, Sept. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author combines the exact, unsteady flow solution of Sedov, wherein the flow velocity in an ideal, perfect, nonconducting gas is a linear function of the distance from a center, axis, or plane of symmetry, with the conservation laws for flow through a shock or detonation wave. Using the Sedov solution to represent the flow behind the wave, author determines the position of the shock envelope, the density and pressure behind the shock, and the initial density ahead of the shock in terms of initial pressure, shock velocity, and time.

Author states that the solutions obtained are applicable in problems of point explosions and detonations of fuel mixtures.

H. A. Stine, USA

1853. Sakurai, T., High subsonic flow with normal shock wave at nearly critical Mach number, *J. Phys. Soc. Japan* **14**, 5, 658–663, May 1959.

An approximate method is described in which the flow about a thin body is divided into two regions, the inner region enclosing the local supersonic region, and the outer comprising the remainder of the flow. Approximate equations used are the Laplace equation in the exterior region, and the parabolic, Prandtl-Glauert equation ($M = 1$) in the interior region. Approximate patching of the solutions is carried out at the common boundary. The method is used to compute the flow over a biconvex profile.

H. Yoshihara, USA

1854. Eckhaus, W., Two-dimensional transonic unsteady flow with shock-waves, AFOSR TN 59–491 (Mass. Inst. Technol., Fluid Dynamics Research Group Rep. 59–3; ASTIA AD 215 844), 79 pp., May 1959.

A study is made of the unsteady flow around an airfoil at transonic Mach numbers, when local supersonic regions terminated by shock waves are present in the vicinity of the airfoil. For the unsteady part of the flow, small-perturbations technique is employed and the interaction with the shock wave is taken into ac-

count. The results permit calculation of the aerodynamic loads on the subsonic portion of an oscillating airfoil in transonic flow, provided that the solution in the supersonic region is known.

From author's summary by A. N. Petroff, USA

1855. Feiler, C. E., Reflection of weak shock waves from nozzles with no flow and critical flow, *ARS J.* **29**, 4, 272–275, Apr. 1959.

The reflection of weak shock waves from nozzles having contraction ratios of 16, 4 and 2, and convergence half-angles of 60, 30 and 15 deg was studied in a shock tube. The experiments were performed with no initial flow through the nozzle and also with critical flow, and the results compared with theory. Contraction ratio, as predicted by theory, had much less effect on reflected shock strength with critical flow through the nozzles than with no initial flow. Convergence angle had little effect on reflected shock strength for either flow condition.

From author's summary

1856. Ferrari, C., On the steady and non-steady transonic flow with attached shock wave ($M_\infty < 1$): New results and conjectures, AFOSR TN 59-338 (Lab. Meccan. Appl. Politecn. Torino TN 12; ASTIA AD 213 659), 31 pp., Feb. 1959.

The question discussed is that of flow, either steady or unsteady, near a point where a shock wave is attached perpendicularly to a smooth wall. It is correctly noted that derivatives of the velocity may be indeterminate behind the shock at the point of attachment. Logarithmic singularities are suggested by a formulation of the problem in terms of a velocity potential behind the shock, for which an approximate equation is given involving the very derivatives whose poor behavior has been indicated. The reviewer finds such an argument difficult to follow, and the result is not in agreement with earlier work, apparently not known to the author, which, while it was inadequate to describe the discontinuities of higher derivatives at the point of attachment, did seem to predict the appearance of fractional powers. Presumably the asymptotic expansion being sought here should include both logarithmic and fractional terms, in accord with the more sophisticated theory of solutions of an elliptic differential equation at the confluence of analytic boundary conditions.

P. R. Garabedian, USA

1857. Grodzovskii, G. L., and Krashchennikova, N. L., Self-similar motions of gas with shock waves, spreading into gas at rest according to a power law (in Russian), *Prikl. Mat. Mekh.* **20**, 5, 936–939, 1959.

Assuming that the speed D of a strong shock varies as the n^{th} power of time, the authors carried out the corresponding similarity solution on a high-speed computer and presented the results in Figs. 1–4. According to Hayes's equivalence principle, the results are interpreted for steady hypersonic flows around axisymmetric bodies given by $r_0 = C\,x^{1+n}$ (Figs. 5, 6, and Table I). It is concluded that for the adiabatic exponent $\kappa = 1.4$ the body nose which minimizes wave drag goes as 0.7 power of x and is fuller than the 0.75 power indicated using Newtonian pressure law. These applications to steady flows essentially match the results of Lees and Kubota [AMR **10** (1957), Rev. 3707].

M. V. Morkovin, USA

1858. Lidov, M. L., Resistance of an unoriented body during motion in a rarefied gas (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12, 1524–1528, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12240.

Author expresses in terms of quadratics the aerodynamic reaction on the oriented element of the surface, moving in a free molecular flow, when the parameter values are fixed. The formulas were obtained by the ordinary methods of the kinetic theory of gases, by ascertaining the number of molecules colliding with the surface's element in a unit of time, at any position taken up by it on the surface, transmitting the amount of motion and energy in mirrored and diffusional reflection of the molecules off the surface. This permitted the recording, in a general form, of the expression for the full force of an arbitrary resistance of a body through the resistance of the elementary area, depending on the physical parameters, geometry and orientation of the body and the element. The paper continues with the introduction of concepts on the ideally-unoriented body; with progressive movement of the center of gravity of this body the vector fixed in the body becomes possessed of the capacity to take every possible direction in space during a period τ, when the time for finding the vector in the determined body angle is proportional to the size of the angle; this rotation of the body takes place sufficiently slowly to ensure that in the period of time τ there shall not be a significant change in parameters. By determining the mean (by time) resistance, author merges the problem of the lateral resistance of an unoriented body in the given assumptions with the calculations for C_x, viewed as a sphere with a surface equal to the surface of a body bulging everywhere, and having the same physical parameters. The calculations for the coefficient C_x are given to cover the cases of mirrored and diffusional reflection of molecules off the body's surface; in the last case special assumptions are introduced.

S. G. Popov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1859. Koga, T., The Boltzmann-Maxwell equation as the fundamental equation of gasdynamics, *Mem. Fac. Engng., Univ. Nagoya* **9**, 2, 268–273 (Research Reports), Nov. 1957.

A qualitative discussion of the concepts important in solutions of nonequilibrium gas problems, such as flow through shock waves, slip flow near solid boundaries, and gases under the influence of magnetoelectric forces. Author points out that in such cases the fundamental equations to be solved are the Maxwell-Boltzmann relations, but that the different types of approximations which can be used may lead to different solutions. Order-of-magnitude parameters are discussed which are useful in deciding which type of approximation should lead to a valid solution.

C. F. Hansen, USA

Boundary Layer

(See also Revs. 1917, 1937, 1944, 1945)

1860. Skopets, M. B., Approximate method for integrating the equations of a laminar boundary layer in an incompressible gas in the presence of heat transfer, *Soviet Phys.-Tech. Phys.* **4**, 4, 411–419, Oct. 1959. (Translation of *Zh. Tekh. Fiz.* **29**, 4, 461–471, Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author considers convective heat transfer under conditions where the heat transfer does not effect the flow field. Integral relations called moment equations are obtained by multiplying the energy equation by powers of y, the transverse coordinate, and integrating over y. The zeroth and first moment equation are two ordinary differential equations which can be solved simultaneously to give an expression for the local Nusselt number in terms of the pressure distribution, the Reynolds number and a "constant." The constant involves integrals of the temperature and velocity gradient across the boundary layer. Values were computed by numerical integration of the Falkner-Skan solutions for Prandtl numbers of 0.73 and 1.00. It is assumed they can be extrapolated to other values of Pr by assuming a cube-root dependence.

With the help of the tables, which represent considerable numerical work, the use of the final formulas appears quite simple. However, no examples of their application or comparison with other methods is given.

Reviewer notes a typographical error in Eq. [3,4] where the numerical coefficient should be 0.243.

W. Squire, USA

1861. Kramer, R. F., and Lieberstein, H. M., Numerical solution of the boundary-layer equations without similarity assumptions, *J. Aero/Space Sci.* **26,** 8, 508–514, Aug. 1959.

The Crocco transformation combined with a Mangler transformation is used to carry the boundary-layer problem for axially symmetric blunt bodies into a form suitable for direct numerical computation without introduction of simularity assumptions. Conditions which in the original problem appear at infinity now are brought to a finite straight line, and the body is transformed to a parallel line. Data can be generated on the stagnation line (perpendicular to the body) to serve as initial values, and since the equations are a parabolic system of two second-order equations, the boundary-value problem is analogous to the slap problem for the heat equation. An implicit difference equation is used to reduce stability difficulties. Special techniques in forming the difference equation result in a linear system of algebraic equations to be solved on any given line of integration, and these solutions are computed from recursion relations generated by back substitution.

From authors' summary by E. Sunderland, USA

1862. Zaat, J. A., Verification of the simple calculation method for three-dimensional laminar boundary layers by means of exact solutions (in German), Nat. Luchtlab., Amsterdam TR F. 202, 24 pp., June 1957.

Approximate method introduced by author [AMR **11**(1958), Rev. 561] is applied to flows for which exact solutions are available for most part: oblique flow past wedges and in corners, flow in neighborhood of stagnation point, flow past yawed cylinders, boundary-layer flow without vorticity-free outer flow. Good agreement is attained in velocity profiles of main and cross flows between approximate and exact solutions after simple modifications to approximate method. These concern alteration to initial value of main-velocity profile parameter and addition of term to analytic description of cross-flow velocity profile in accelerated range of outer flow. Cross flow is still to remain small compared to main flow in boundary layer. P. S. Granville, USA

1863. Zysina- Molozhen, L. M., A study of the effect of a longitudinal pressure gradient on the development of boundary layer, *Soviet Phys.-Tech. Phys.* **4,** 4, 401–410, Oct. 1959. (Translation of *Zh. Tekh. Fiz.*, **29,** 4, 450–461, Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The results of an extensive series of measurements of turbulent velocity distributions in incompressible flow are studied by assuming a logarithmic profile and determining the dependence of the constants on a Reynolds number and a pressure-drop parameter. Some studies of the effect of the free-stream turbulence level are also included. An interesting feature is the emphasis on the transition region and the discussion of empirical expressions for the location and extent of the transition zone.

It is unfortunate that the experimental data which appears to be a valuable contribution is not reported in sufficient detail to permit independent analysis. The only comparison with prior work is with the work of Gruschwitz [*Ing. Arch.* **2,** 321–346, 1931]. A correlation with the extensive series of measurements carried out by Schubauer and Klebanoff at the Bureau of Standards [AMR **4** (1951), Rev. 352] would be desirable.

Reviewer notes that the length δ^{**} used in forming the correlating parameters is not defined. On the basis of Eq. [4] he believes that it is the momentum thickness usually denoted by θ rather than the energy thickness for which the symbol δ^{**} has been used in the literature. W. Squire, USA

1864. Gersten, K., Corner interference effects, Dtsch. Forschungsanstalt Luftfahrt, Ber. 108, 23 pp., 1959.

Interference skin friction, is defined as the difference between the frictional resistance of two plates forming a rectangular corner and a flat plate of the same length and surface. It is very small and negative in a laminar and positive in a turbulent region of the boundary layer. The coefficient is proportional to $1/Re$ (Re = Reynolds number) for both laminar and turbulent flow. The interference displacement thickness of the boundary layer is of the same order of magnitude as without interference. This coefficient is proportional to $1/\sqrt{Re}$, for both laminar and turbulent flow. Near the corner, the transition from laminar to turbulent flow occurs further upstream than in the two-dimensional case. Very near the corner, however, there remains a laminar sublayer. These results are valid for constant velocity and pressure of the outer flow. Some preliminary results are given about the effect of a pressure gradient on the interference effects.

A. Betz, Germany

1865. Pallone, A., Analysis of the laminar compressible boundary layer characteristics over an isothermal flat plate with fins, AFOSR TN 59-275 (Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech. Rep. 468; ASTIA AD 212 709), 56 pp., Feb. 1959.

This paper deals with a method of insulation against aerodynamic heating by artificial thickening of boundary layer. Small streamwise fins normal to the surface are used. The problem is formulated based on the averaged contributions of fins to the basic equations. The solution is applicable to fin heights smaller than the boundary-layer thickness and spacing proportional to the square root of distance from the leading edge. Results indicate that both shear stress and rate of heat transfer decrease with increase in fin height, decrease in fin spacing and increase in free-stream Mach number. Reduction may amount to 1/3 of that of a simple flat plate. The method also implies that fin height is greater than fin spacing and that fin dimensions are greater than the mean-free-path of the gas. Fin thickness is not considered but might be significant in the practical problem. It is believed that some of the above restrictions may be removed by treating the problem as equivalent to having an average slip flow near the wall formed by the top edges of the fins with corresponding modification of the conditions at this wall.

S. L. Soo, USA

1866. Savulescu, St. N., Behavior of some solutions of the three-dimensional boundary layer in the hypothesis of typical velocity and temperature profiles (in Roumanian), *Studii Si Cercetari Mecan. Appl.* **10,** 3, 695–710, 1959.

Author proposes an approximate method based on the use of a change of variable which leads to the so-called typical velocity and temperature profiles. It is assumed that the velocity profiles in the three-dimensional boundary layer, considered upon two directions whose bisector is the velocity of the external flow, become typical profiles if this change of variable is applied. Calculations pertaining to the integration of the boundary-layer equations are thus substantially simplified if the streamlines of the external flow may be approximated by a net of straight lines. Method is applied to the study of an incompressible laminar boundary layer on a circular cylinder inclined by 45° with respect to the undisturbed stream velocity. The streamlines determined at the wall do not differ sensibly from those obtained through other methods. Further, the compressible laminar boundary layer

on a thermically insulated delta wing is discussed, assuming the external flow to be conical; at the tip and leading edge region, the results do not correctly express the phenomenon.

T. Oroveanu, Roumania

1867. Shidlovskii, V. P., On the influence of slip in viscous gas flow past a semi-infinite flat plate (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 83–90, Sept. 1958.

The starting point of the investigation is Navier-Stokes equations of comprssible flow (including energy equation) simplified according to the dimensional analysis of Prandtl. Thus only the first momentum equation, continuity and energy are considered, the second momentum equation implying that the pressure gradient in the vertical direction is constant. The case under consideration is that of a two-dimensional flow over a flat plate. The boundary conditions refer to a slip flow in the Knudsen-von Smoluchowski formulation, i.e., there are velocity and temperature jumps at the surface of the plate. Author uses transformation of coordinates proposed by A. A. Dorodniczyn ["Boundary layer in compressible gas," *Prikl. Mat. Mekh.* **6,** p. 449, 1942] which actually is identical to Kalikhman's and Chapman and Rubesin's transformation. Introducing the notion of the stream function author obtains two partial differential equations (of third and second order, respectively) whose solutions are proposed in form of series expansions. These inserted into equations, furnish, by the standard procedure of equating the coefficients of the resulting series to zero, an infinite system of equations for the successive velocity (u_1, u_2, ...) and temperature functions (T_1, T_2, ...). Solutions of the first of these equations jointly with the boundary conditions furnish the expressions for the first approximations to the velocity and temperature; which together with their derivatives are represented graphically.

M. Z. v. Krzywoblocki, USA

1868. Becker, E., Friction influences in a tube wind tunnel (in German), Mitt. Max-Planck Inst. Stromungsforschung no. 20, 74 pp., 1958.

An analysis is presented of the flow in a tube wind tunnel, a relatively simple device related to a blow-down wind-tunnel that is useful for the production for a short period of time of a steady supersonic flow. The discussion starts with a brief review of the unsteady gas dynamics of an inviscid fluid in a tube wind tunnel. There follows a detailed analysis of the behavior of the unsteady turbulent boundary layer that exists along the wall, and of the degree to which its presence affects the flow throughout the entire device. The paper closes with the presentation of some experimental results that essentially confirm the theoretical results.

J. R. Spreiter, USA

1869. Baron, J. R., The binary-mixture boundary layer associated with mass transfer (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **4,** 67–77.

Analysis is made of the effect of injection of a foreign fluid into the laminar compressible boundary layer. Governing equations for the system with appropriate boundary conditions are presented. Numerical solutions are effected. Results are presented for effect in heat transfer, surface temperature, skin friction, etc.

H. N. McManus, Jr., USA

1870. Cook, W. L., Anderson, S. B., and Cooper, G. E., Area-suction boundary-layer control as applied to the trailing-edge flaps of a 35° swept-wing airplane, NACA Rep. 1370, 33 pp., 1958.

Three-component force data and pressure data presented show the effects of area-suction boundary-layer control on the longitudinal characteristics of a 35° sweptwing airplane. Also presented are pilots' opinions of the effects of boundary-layer control on the handling qualities of the airplane.

From authors' summary

1871. Experiments on distributed suction through a rough porous surface by Cambridge Univ. Aero. Lab., *Aero. Res. Counc. Lond. Rep. Mem.* 3118, 6 pp., 1959.

1872. Binder, R. C., Investigation on the effects of local energization of the boundary layer in curved diffusers, WADC TR 58-23 (PB 131 748; ASTIA AD 150 995), 28 pp., Jan. 1958.

At Purdue University an experimental study was made of transonic flow in a curved diffuser with and without a vortex generator. The vortex generator, consisting of a flat piece of sheet metal with triangular projections, was mounted on the convex wall of the diffuser. Results were organized in terms of pressure coefficient. The vortex generator increased the pressure coefficient especially in the high Mach number test region.

The main reason for introducing a device such as the vortex generator into a channel or blade passage is to delay the point of flow separation. This report gives the results obtained on one type of vortex generator in a curved diffuser. In the particular model channel tested the optimim position of the vortex generator, as judged by the largest pressure coefficient over the widest Mach number range, was found to be about 33% of the chord. This vortex generator, then, effectively increases the pressure coefficient, and delays separation.

From author's summary

1873. Hammitt, A. G., and Hight, S., Scale effects in turbulent shock wave boundary layer interactions, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 362–382.

Tests were made in two wind tunnels (4 in. × 8 in. and 2 in. × 2½ in.) at Gas Dynamics Laboratory, Princeton University on separation induced by incident-reflected shock wave, of 10° strength, impinging on turbulent boundary layer. Static pressures and velocity traverses were made for Reynolds numbers (based on displacement thickness in absence of impinging shock) from 0.38×10^5 to 3.85×10^5. The number of boundary-layer thicknesses over which interaction occurred became smaller as $Re\delta^*$ increased for untripped layers, and the pressure ratio to cause initial separation also increased with $Re\delta^*$—a result opposite to that found in AMR **12** (1959), Rev 4011. For tripped layers no definite trends were found; the pressure ratios and gradients at separation and re-attachment were relatively independent of $Re\delta^*$. Also, it was possible to obtain interaction length either increasing or decreasing with $Re\delta^*$ as trip coefficient and location of transition were varied.

R. N. Cox, England

1874. Chung, P. M., Shielding stagnation surfaces of finite catalytic activity by air injection in hypersonic flight, NASA TN D-27, 20 pp., Aug. 1959.

Solutions are obtained from which the heat-transfer rate to surfaces with finite catalytic activity and air injection can be calculated for the stagnation region provided the boundary layer is chemically frozen. Such conditions exist, for instance, at a flight altitude around 200,000 ft, and flight velocities between 10,000 and 25,000 fps. The simplifications introduced by L. Lees are applied to the boundary-layer equations. In this way the momentum equation is reduced to the Blasius form, and the energy and diffusion equations for atoms become similar. Numerical computations show that large decreases in the total heat flux to the surface can be effected by air injection. The total heat flux consists of the heat conducted into the surface and the heat liberated at the surface by the re-combination of atoms. Both portions are decreased by air injection, the second part as a consequence of the decrease in the mass fraction of the atoms arriving at the surface.

E. R. G. Eckert, USA

1875. Rosner, D. E., Steady-state surface temperatures in dissociated high-speed gas flows, *J. Aero/Space Sci.* **26,** 6, 384–385 (Readers' Forum), June 1959.

Interesting paper treats problem of insulated wall temperature assumed by a surface in a partially dissociated supersonic gas stream. Specifically, a simplified theory is developed containing a "catalytic parameter" which, in addition to usual terms, contains ratio of characteristic diffusion time to characteristic reaction time at surface. Limiting examples are illustrated with this parameter.

Paper contains useful selective list of 12 references on flow problems including surface reactions.

P. P. Wegener, USA

1876. Rozin, L. A., Some questions relating to the theory of a nonstationary boundary layer (in Russian), Avtoref. Diss. Kand. Fiz.-matem. Nauk, Leningrad Politekhn. In-ta, Leningrad, 1958; *Ref. Zh. Mekh.* no. **11**, 1958, Rev. 12723.

1877. Nickel, K., External boundary condition on the boundary layer differential equation (in German), *ZAMM* **38**, 9/10, 400–401, Sept./Oct. 1958.

1878. Brown, F. N. M., The organized boundary layer, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 331–349.

Smoke studies of the flow past two- and three-dimensional bodies were made in smoke tunnel of very low fine turbulence level at University of Notre Dame. It was found that laminar separation was always accompanied by formation of a periodic series of vortical elements within the separated layer. In adverse pressure gradients (as on upper wing surface) and in zero, or even favorable, gradients on long bodies with no radial flow, this series of elements was thought to be the mechanism of transition. The translational speed of the elements was 85% of the free-stream velocity within zero gradient boundary layers, and in wakes of two-dimensional bodies. Author considers elements to be of horseshoe form. Frequency of periodic motion was controllable by audio oscillations of from 0.8 to 1.2 times critical frequency.

R. N. Cox, England

Turbulence

(See also Revs. 1836, 1837, 1873)

Book—1879. Hinze, J. O., Turbulence, New York, McGraw-Hill Book Co., Inc., 1959, ix + 586 pp. $15.

This book developed from a series of lectures to chemical engineers on the modern theory of turbulent flow.

The chapter headings are: 1. General introduction and concepts; 2. Principles of methods and techniques in the measurement of turbulent flows; 3. Isotropic turbulence; 4. Nonisotropic turbulence; 5. Transport processes in turbulent flow; 6. Nonisotropic free turbulence; 7. Nonisotropic "wall" turbulence. There is also an appendix on Cartesian tensors.

Reviewer believes that this book is a valuable contribution to the literature which may, however, interest specialists in fluid mechanics more than its intended audience. The principal features of the book are a very large collection of curves of experimental results of various workers and a detailed exposition of the mathematics of the statistical theory of turbulence. The statement in the publishers blurb "reduces the use of mathematics to a minimum" is not an accurate description. For example, the first chapter contains a hundred numbered equations and about as many unnumbered ones in 69 pages!

The discussion of specific configurations is largely confined to those configurations where hot-wire measurements are available so that the structure of the flow can be discussed. As a result of this, configurations of interest to chemical engineers such as flow in an annulus are not considered. The analysis of these configurations is largely by mixing-length theories and there is always a careful comparison of the prediction of the various variants with experiment. Unfortunately the work of Ferrari [AMR **12** (1959), Rev. 4624] on the application of the statistical theory to shear flows, which would have been useful in unifying this part of the book, was not available.

The large number of figures and equations justifies the price of the book, but the index is somewhat skimpy. For example, momentum and displacement thickness are not indexed though they are briefly but adequately treated.

The fact that a well-written book of this size, which contains very little background material, leaves many interesting topics uncovered is testimony to the current interest and rapid development of turbulence research.

W. Squire, USA

1880. Tsuji, H., A contribution to the energy decay law of isotropic turbulence in the initial period, Aero. Res. Inst., Tokyo University, Rep. 345, 87–108, May 1959.

Author points out that linear decay law, first derived theoretically by Batchelor, is based on the assumption of partial self-preservation of velocity correlation functions, but there is involved a self-contradiction that eventually necessitates the premise of complete self-preservation of correlation functions. On the other hand, Lin's decay law, which was derived by assuming similarity of spectrum for wave numbers except at small end, holds only after neglecting the self-preservation of correlation functions near $r = 0$. These important characteristics are confirmed by experiments. Author assumes that the partial self-preservation of correlation functions holds and S and G stay constant during decay, as confirmed by experiments. Energy and vorticity decay equations are simultaneously solved under the above assumption, and effect of initial conditions on the energy decay is examined. The calculated results agree with energy decay measurements behind one and two grids.

From author's summary by M. S. Uberoi, USA

1881. Ohji, M., On the theory of homogeneous axisymmetric turbulence, *Rep. Res. Inst. Appl. Mech., Kyushu Univ.* **6**, 22, 63–83, 1958.

Author develops basic mathematical identities for correlation tensors of homogeneous turbulence having symmetry about an axis. Formulas of G. I. Taylor and G. Batchelor for the effect of wire gauze on turbulence [*Quart. J. Mech. Appl. Math.* **2**, 1–29, Mar. 1949; AMR **3** (1950), Rev. 554] are interpreted as an application of author's general formulas. No other applications are given.

G. Birkhoff, USA

1882. Taneda, S., Downstream development of the wakes behind cylinders, *J. Phys. Soc. Japan* **14**, 6, 843–848, June 1959.

Wake development behind circular cylinders and flat plates was investigated in the research water tanks. The aluminum dust method was used to observe the flow patterns.

At the intermediate Reynolds number range the Kármán vortex streets are formed in the wakes behind cylindrical obstacles. But these primary Kármán vortex streets are not stable. They are more and more deformed as the distance from the obstacle is increased, and finally break down.

Thereafter, however, the wake in most cases begins to rearrange itself again into a configuration of the Kármán vortex street. The dimension of the secondary Kármán vortex street thus produced is much larger than that of the primary one. For the circular cylinder, when Reynolds number is lower than about 150, the ratio of the wavelength of the secondary vortex street to that of the primary one is about 1.8 to 3.6, while it is about 10 when Reynolds number is higher than about 150.

Sometimes the secondary Kármán vortex street simply decays by viscous diffusion as it moves downstream, but in most cases it rearranges itself again to the next Kármán vortex street.

From author's summary

1883. Shaver, R. G., and Merrill, E. W., Turbulent flow of pseudoplastic polymer solutions in straight cylindrical tubes, *AIChE J.* **5,** 2, 181–188, June 1959.

This paper reports experimental results on the flow of non-Newtonian fluids (see following review) in a circular pipe. Besides pressure drop measurements, the mean velocity distribution was also measured. Some dye injection studies were also made. There is some theoretical discussion of the results, particularly of the pressure fluctuations observed in the transition range.

Reviewer believes that the availability of experimental mean velocity distributions is noteworthy and may stimulate additional theoretical work on this problem. W. Squire, USA

1884. Dodge, D. W., and Metzner, A. B., Turbulent flow of non-Newtonian systems, *AIChE J.* **5,** 2, 189–204, June 1959.

This is a pioneering theoretical investigation of the turbulent flow in a circular pipe of fluids with a stress-shear rate relation of the form $\tau = k\,[\varepsilon du/dr)^n]$. Fluids for which $n \neq 1$ are customarily referred to as non-Newtonian. The authors generalize the usual velocity defect and wall similarity laws and derive a logarithmic velocity distribution by assuming a region where both are valid, a derivation which is becoming very common in recent books and papers on turbulent flow. A pressure drop law analogous to the usual Prandtl-von Karman expression, but utilizing a generalized Reynolds number, is proposed and compared with experimental data obtained by the authors.

Unfortunately, no measurements of the velocity distribution, such as those of Shaver and Merrill (see previous review), were available. Reviewer awaits such a comparison with interest.

W. Squire, USA

1885. Korst, H. H., and Chow, W. L., Compressible non-isoenergetic two-dimensional turbulent (Pr_t = 1) jet mixing at constant pressure—auxiliary integrals, heat transfer and friction coefficients for fully developed mixing profiles, AFOSR TN 59–380 (59–20) (Univ. Illinois, Engng. Exp. Sta., Mech. Engng. Dept. TN 392-4; ASTIA AD 211 328), 35 pp., Jan. 1959.

Definitions and graphical presentation of auxiliary functions, calculated on a high-speed digital computer (ILLIAC), pertaining to the two-dimensional non-isoenergetic turbulent jet mixing problem. Theoretical friction coefficients and Stanton numbers for such mixing regions are given. The results facilitate especially the treatment of jet-slipstream interaction (base pressure and base temperature problem). From authors' summary

1886. Szablewski, W., Turbulent diffusion of hot axially symmetrical jet in an external stream, Part I (in German), *Ing.-Arch.* **26,** 5, 358–377, Oct. 1958.

Author writes the equations of the turbulent diffusion of a hot axially symmetrical jet (whose velocity on the axis is u_0) in an external stream of velocity u_1, assuming

$$\overline{u'v'} = \varepsilon \frac{\partial \bar{u}}{\partial r}; \quad \overline{v'T'} = E\varepsilon \frac{\partial T}{\partial r}; \quad \overline{v'\rho'} = \varepsilon E \frac{\partial \bar{\rho}}{\partial r} \qquad [1]$$

where the transfer coefficient ε has the expression proposed by Prandtl. E is an empirical constant and the other symbols have their usual meanings. The system of the equations giving the components $\bar{u}$ and $\bar{v}$ of the velocity and temperature $\bar{T}$ is solved for the values of the abscissa x, measured along the axis, assuming as *initial profiles* (for $x = 0$) for the aforementioned quantity the ones obtained for the corresponding two-dimensional problem, studied by the author in another work, and using therefore a step-by-step method.

The results computed by the author for several values of $(u_0 - u_1)/u_0$; $(T_0 - T_1)/T_0$ (T_1 = temperature of the external stream) show that both $(u - u_1)/(u_0 - u_1)$ and $(T - T_1)/(T_0 - T_1)$ vary in the cross section of the jet almost similarly along the axis and that the breadth of the mixing field for the temperature is higher than for the velocity (while its length is shorter); these results appear to be in accordance with experimental ones.

Reviewer believes that, while the first two parts of Eq. [1] have a theoretical basis, the third one is more difficult to justify, if E has the same value of the one corresponding to the second of the same [1]. Also, reviewer does not clearly understand what is the section of the jet which is assumed as initial in relation to the mouth of the nozzle. C. Ferrari, Italy

Aerodynamics

(See also Revs. 1837, 1845, 1850, 1853, 1854, 1856, 1867, 1899, 2011)

1887. Hurley, D. G., Note on the forces that act near the centre and the tips of a swept-back wing, *Aero. Quart.* **10,** 2, 127–144, May 1959.

The momentum equation is used to calculate the drag that acts near the tip of a semi-infinite sweptforward wing of constant chord that is at zero incidence to a uniform stream of incompressible, inviscid fluid. The drag is given as a function of wing section and angle of sweep and is shown to be unaffected by shaping the tip. The results may be used to calculate the drag that acts near the center and the thrusts that act near the tips of a sweptback wing, provided that its aspect ratio is sufficiently great for the regions where the different forces act to be separated. Some results due to Neumark and to Küchemann and Weber suggest that this will be so provided that the aspect ratio is greater than about two. The results are combined with some due to these authors to estimate the spanwise extent of the forces. It is found that this extent decreases as the angle of sweep is increased and that it depends quite markedly on the wing section. [See also AMR **10**(1957), Rev. 2617.]

From author's summary by S. B. Berndt, Sweden

1888. Mangler, K. W., and Smith, J. H. B., A theory of the flow past a slender delta wing with leading edge separation, *Proc. Roy. Soc. Lond.* (*A*) **251,** 1265, 200–217, May 1959.

Conical flow past an unyawed flate plate wing in the form of a narrow isosceles triangle at small incidence in a uniform stream is investigated on the basis of slender-body theory. Fluid separates along lines near the trailing edges to form a spiral vortex sheet above and inboard of the edges. Improvements in previous methods are introduced in calculating the form of the spiral sheet near its center, and the form of the sheet between the leading edge and a point not too distant from the center of the spiral. The geometry of the sheet is exhibited graphically as a function of the ratio of the incidence angle to the aspect ratio. Pressure distributions, chord loadings, and forces on the wing, are also exhibited, and comparison is made with other theoretical and experimental results. E. E. Jones, England

1889. Mello, J. F., Investigation of normal force distributions and wake vortex characteristics of bodies of revolution at supersonic speeds, *J. Aero/Space Sci.* **26,** 3, 155–168, Mar. 1959.

Paper presents results of experimental investigation at Mach number 2, and compares methods of predicting flow properties in vicinity of body. Author shows limitations of theoretical prediction of characteristics using Van Dyke's hybrid theory [AMR **4**(1951), Rev. 2575] and either Kelly's [*J. Aero. Sci.* **21,** 8, 549–555, Aug. 1954] or Allen and Perkin's [AMR **5**(1952), Rev. 3455] method of viscous contribution calculation. He presents empirical correlation for high angles of attack of given body nose shape and uses results to predict characteristics of bodies with the same nose shape and various fineness ratios. Experimental results confirm validity of this empirical method. Paper shows limited

extension of results to Mach number 1.5, nose shape variation, nose fineness ratio. Analytical method for determination of vortex strength and location is given and applied to typical model. Good correlation is shown between results of method and measurements on given model at Mach number 2.

Reviewer believes method to be major contribution to wing-body design techniques, and limited extension possible to higher Mach numbers. H. L. Bloom, USA

1890. Patraulea, N. N., A simplified method for the calculus of jet-flapped wings (in Roumanian), *Studii Si Cercetari Mecan. Appl.* **10,** 2, 351–365, 1959.

Author gives a simplified method whereby the lift and the induced drag of finite span jet-flapped wings may be readily computed, making use of the following assumptions: (1) the Prandtl concept of the lifting line for the total circulation around the wing and the jet sheet may be applied due to the fact that the spanwise vortices within the jet sheet which contribute to the total circulation do not extend to great distances downstream of the wing, (2) the spanwise distribution of the circulation is elliptical, i.e., the distribution of the chords and jet momenta is elliptical, and (3) the flow and pressure distribution around the median airfoil of the wing may be computed in the same way as for a jet-flapped airfoil of infinite span, but taking into account the mean value of the induced velocity near the wing, i.e., neglecting the variation of this velocity along the airfoil and the jet line.

In this way, simple formulas are obtained for the lift, induced drag and effective angle of attack. Thus it is shown that except for the extreme cases of very low aspect ratios and strong jets, the maximum lift is not too much reduced by the effect of the finite span; however, because of the high induced angles, very high angles of attack are necessary. Qualitative comparison of available experimental data show agreement with the theory.

The influence of the fuselage is discussed and a generalization of the theory for arbitrary distributions of the circulation is also given. L. Dumitrescu, Roumania

1891. Shidlovskii, V. P., Approximate method of calculating high Mach number flows past two-dimensional forebodies (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 3, 156–162, Mar. 1958.

Problem considered is that of small disturbance, hypersonic, steady two-dimensional flows (hypersonic analogy). Introducing a stream function and characteristic parameters λ and μ (which in homentropic flow would reduce to the Riemann variables), author outlines two methods of solution based on approximate relations between pressure and λ and μ. A numerical example (10% thick circular arc forebody at $M = 5$) yields accuracy comparable with that of the shock expansion theory. Reviewer notes that equally accurate results can be obtained by the very much simpler slender airfoil approximation to the shock expansion method [A. J. Eggers, et al., NACA Rep. 1123, 1953; see AMR **5,** Rev. 3494; **6,** Rev. 968] and believes author's method to be mainly of mathematical interest. H. K. Zienkiewicz, England

1892. Wykes, J. H., Casteel, G. R., and Collins, R. A., An analytical study of the dynamics of spinning aircraft, Part I, Flight test data analyses and spin calculations, WADC TR 58-381 (ASTIA AD 203 788), xxi + 206 pp., Dec. 1958.

This report presents the results of a study designed to show the feasibility of avoiding current limitations of spin test facilities by the use of an analytical approach to predicting spin characteristics. Analyses of flight test data were made to show the relative importance of weight, inertia, engine and aerodynamic influences acting during a spin of a typical fighter airplane. The effects of the aerodynamic factors are shown to be highly important. Problems encountered during low-speed wind-tunnel tests to obtain applicable aerodynamic stability and control data are discussed, including tunnel blockage at high angles of attack, Reynolds number effects, and use of grit tripping to obtain simulated high Reynolds number data. No dynamic model was tested for rotary derivatives, but a "strip" technique was developed which gives first order of magnitude influences. Both the static and rotary derivative data were used in a number of six-degrees-of-freedom spin calculations. These spin calculations were evaluated by comparing them against flight test data. These comparisons show that it is possible to calculate the response characteristics of an airplane through all phases of the spin from the incipient phase through recovery. Also, a comparison between a high Mach number spin entry calculation and flight test data was made. It was indicated that if good data are available, the calculating techniques used to study low-speed spins are also applicable to high-speed maneuvers with slight modification. The possibility of utilizing these techniques to study space vehicle reentry dynamics is pointed up.

From authors' summary

1893. Wykes, J. H., Casteel, G. R., and Collins, R. A., An analytical study of the dynamics of spinning aircraft, Part II, Wind tunnel tests, WADC TR 58-381 (ASTIA AD 203 789), ix + 58 pp., Dec. 1958.

The results of a series of low-speed wind-tunnel-force tests of the F-100D from 0 to 90° angle of attack and sideslip angles of 0° to 20° are presented. These data were obtained to support an attempt to calculate the spinning characteristics of the airplane. These data include configuration buildup and control effectiveness data. In addition, the effects of Reynolds number and the effect of tripping the fuselage boundary layer to simulate high Reynolds number flow were investigated. A simple but effective way of correcting data for tunnel blockage effects when a model is at high angles of attack is also presented.

From authors' summary

Vibration and Wave Motion in Fluids

(See also Revs. 1586, 1596, 1836, 1904, 2024, 2056, 2063, 2065, 2102)

1894. Kaichev, P. A., Graphical method of investigating oscillations in a surge tank supplied by two head race canals (in French), *Houille Blanche* **14,** 3, 361–365, May/June 1959.

Starting with the classical surge tank theory author applies the graphical method to investigate the fluctuations of the pressure head and of the outflow velocity in a surge tank of a hydroelectric power station supplied by two different reservoirs via two head race canals. The graphical constructions are carried out for instantaneous opening of the valve to its full, and to a partial, cross section; and also for an instantaneous closure of the valve from a full-flow and from a partial-flow condition. It is assumed that the relationship between the head losses in the two canals during steady flow conditions is valid also during unsteady flow conditions. This assumption is correct only if certain conditions are fulfilled, details of which are given. If these conditions apply, then the calculations are identical with those used in the ordinary case of a surge tank supplied by one reservoir. Author refers to the previous work of M. V. Goutkin: "General method of calculation of a surge tank fed by two influx channels," published in *Houille Blanche* 1948, no. 3.

K. J. DeJuhasz, USA

1895. Asatur, K. G., Calculation for the water-hammer effect taking into account the friction forces (in Russian), *Gidrotekh.*

Stroit. no. 3, 44–47, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12600.

Means are studied of calculating the loss of pressure in computations of water-hammer effect by using the method of characteristics. These losses are determined for some mean value for the given portion of the pipe and for the given interval of time for discharge. Author proposes a mean value for such discharge the finding of which would not involve the solution of a quadratic equation which would be necessary in the calculation using the fictitious "resistance joints" [M. A. Mostkov, A. A. Bashkirov, "Calculations for the hydraulic hammer effect," Gosenergoizdat, 1952]. N. A. Kartvelishvili

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1896. Combes, G., The use of a graphical method for investigating transient phenomena in water supply systems (in French), *Houille Blanche* **14,** 3, 366–378, May/June 1959.

Hydraulic systems for large city water supply and agricultural irrigation often necessitate complicated installations, comprising automatic control equipment. Often it becomes difficult to investigate operational stability by standard analytic methods; the graphical method overcomes these difficulties, and by virtue of its pictorial nature provides an insight into the influence of the various factors. The graphical method is explained in detail on a system comprising a reservoir with a free surface, a long conduit, a regulating valve at the end of the conduit, and a supply basin the level of which is to be kept constant by the regulating valve. Several other examples are given on modified systems having various types of regulating valves for closer and more refined regulation of the basin level. Author refers to the previous work of L. Bergeron: "Le Coup de Belier" (Water hammer). The detailed drawings show clearly the successive steps to be followed in the application of the method and its interpretation in terms of the influence of the several variables.

K. J. DeJuhasz, USA

1897. Markavich, N. M., Experimental investigation of a transient motion of gas when flowing out of a vessel (in Russian), *Ucb. Zap., LGU* no. 217, 185–194, 1957; *Ref. Zh. Mekh.* no. **11,** 1958, Rev. 12399.

Descriptions are given of the lay-out of the experimental plant and the procedure adopted for carrying out the experiment. A comparison of the experimental data with the data for the theoretical calculation, which was made on the assumption of the quasistationary nature of the flow-process, gave sufficiently good agreement with an error in measurement of the order of 5%.

A. I. Poshkarev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1898. Harron, R. J., A drift-monitoring system and a rapid calibrating technique for the capacitive wave profile recorder, Nat. Res. Counc., Canada, Rep. MI 818A, 14 pp., Mar. 1959.

This report describes a method for monitoring the drift which may occur in the capacitive wave profile recorder described in NRC Report MI-818, and also a technique for the rapid calibration of the capacitive probes. A voltage, simulating the at-rest water level, is set up on a potentiometer and is used as a reference for monitoring drift in the system. For calibration, a remotely-controlled motor positions the probe at either of two preset limits approximating the maximum and the minimum height of the waves to be measured. From author's summary

Fluid Machinery

(See also Revs. 1695, 1722, 1753, 1769, 2012, 2014)

Book—1899. Markov, N. M., Calculation of the aerodynamic characteristics of turbine blading (Translated from the Russian), East Orange, N. J., Associated Technical Services, Inc., 1958, vi + 114 pp. $27.50.

The book contains the following. Part I. Cascaded blades of infinite and finite lengths: I. Calculation of profile losses in cascaded blades of infinite length; II. Expression for the calculation of end losses in a cascade; III. Calculation of end losses in the cascade; IV. Empirical method for the calculation of end losses, comparison of calculated results with experimental data; V. Calculation of the exit angle of flow from the cascade; VI. Sample calculations of the aerodynamic characteristics of cascades.

Part II. Turbine stages: I. General information on elementary stages; II. Correlation of the aerodynamic characteristics of two-dimensional cascades and of stage characteristics; III. Flow of fluid in the boundary layer on the blades during rotation of the rotor; IV. Sample calculations of the aerodynamic characteristics of a turbine stage.

There are 68 references; most of them are in Russian and a few in English. Although this book does not mention the more recent unsteady aerodynamic problems, it should be of interest to designers. W.-H. Chu, USA

1900. Wossog, G., Calculation of pressure distribution according to Howell's cascade theory (in German), *Maschinenbautechnik* **8,** 5, 263–267, May 1959.

The problem treated is the conformal transformation of a given "pear-shaped" form to a circle, a problem which is part of the process of finding the potential flow velocity distribution on an airfoil [Theodorsen, T., and Garrick, I. E.: "General potential theory of arbitrary wing sections," NACA Rep. 452, 1933] or on a cascade [Howell, A. R.: "A theory of arbitrary airfoils in cascade, *Phil. Mag.* **39,** no. 299, Dec. 1948].

The conventional procedure consists of choosing arbitrary points on the profile which are related through all transformation functions to the points on the pear-shaped form. These points are then transformed by a Fourier series to the points on the circle. This author chooses points on the pear-shaped form which are separated by radial lines including a *constant* angle. Although the corresponding points on the profile may not be ideally spaced, and therefore more points must be calculated, a large reduction of the computational work results (of the order of 10 fold). An example of 24 points needed 2½ hours computation.

H. P. Eichenberger, USA

1901. Emery, J. C., Herrig, L. J., Erwin, J. R., and Felix, A. R., Systematic two-dimensional cascade tests of NACA 65-series compressor blades at low speeds, NACA Rep. 1368, 85 pp., 1958.

A two-dimensional low-speed porous-wall cascade tunnel investigation has been conducted to establish the performance of the NACA 65-series compressor blade sections over the useful range of inlet angle, solidity, and section camber. Design points for optimum high-speed operation are presented. The loading limitation is determined for some conditions. Trends of section operating range with increasing section camber are determined for the four inlet angles tested. From authors' summary

1902. Salomann, V., Cavitation and NPSH requirements of various liquids, *ASME Trans.* **81**D (*J. Basic Engng.*) 2, 167–180, June 1959.

Test results on the net positive suction head, NPSH, requirements for centrifugal pumps handling water up to 420 F, some hydrocarbons, and Freon-11 are presented. Satisfactory pump performance was observed with net positive suction heads less than those required by the pump on cold water. A direct measurement of NPSH was attempted and is reported. The cavitation process is discussed and a correlation and method of prediction for all liquids is proposed.

This paper and the written discussion thereto makes a most valuable beginning of research which is vitally necessary to the pumping of high-temperature liquids. In spite of severe difficulties in temperature observations, etc., author has succeeded in obtaining and presenting data of fundamental value to designers.

H. H. Anderson, Scotland

1903. Yeh, H., and Eisenhuth, J. J., The unsteady wake interaction in turbomachinery and its effect on cavitation, *ASME Trans.* **81**D (*J. Basic Engng.*), 2, 181–189, June 1959.

After brief survey of past theoretical treatments of unsteady effects of blade row wakes on pressure and velocity in axial machines, authors develop modified expression for pressure distribution. First step is single, thin airfoil under sinusoidal gust. Use of linearized theory requires small mean perturbation velocity and implies that vorticity is carried by main flow, leaving induced flow irrotational, but unsteady. Next steps are superposition of sinusoidal gusts, and ingenious use of "equivalent angle of attack" for small angles of attack, based on fact that chordwise distribution of pressure perturbations is of same functional form for all gusts, therefore also for steady-flow pressure at constant angle of attack.

Transition to turbomachinery is treatment of blade row wakes as periodic gusts affecting downstream rows. Fourier analysis uses cosine curve for wake velocity profile, basing this on experimental evidence. Result is relationship between velocity defect in wakes and wake wave numbers. Authors examine maximum values of "equivalent angle of attack" responsible for setting off cavitation. Assumption of narrow, widely spaced wakes leads to simplified, known integral, yielding influence of wake, especially when center of wake hits leading edge of airfoil. Theoretical parametric curves of maximum equivalent angle of attack against wake spacing, for different wake widths, exhibit expected asymptotic trends. Plot of asymptotic values of maximum equivalent angle of attack against wake width serves as comparison with tests.

Experimental work is designed to simulate assumed conditions. Wake survey provides limits of validity of assumed wake profile. Cavitation tests are run first for rotor in free stream, then in wakes of smooth or rough struts. Other variables are: advance ratio and distance between strut and rotor. Results indicate that at high advance ratios smooth strut wake has no effect on cavitation; not so, rough strut. Experimentally determined maximum equivalent angles of attack are considerably below predicted curve, but general trend is clearly present, demonstrating equivalence of unsteady pressure perturbations and quasi-steady angle-of-attack effect.

T. Ranov, USA

1904. Carter, A. D. S., A contribution to the theory of flow stability in multi-stage axial compressors, *Aero. Quart.* **10,** 2, 163–182, May 1959.

Previous theories on the surging of axial compressors have been based on a quasi-static theory, whereas a finite rate of growth of the circulation around each blade must occur in practice. An examination of this factor is made in this paper, studying the stability with respect to small changes in speed instead of mass flow, as in the normal approach. Effects of capacity are neglected. It is concluded that an instability occurs in the last stage of the compressor, even when that stage is itself unstalled, which could give rise to surge. It has been found necessary to introduce one empirical factor into the analysis but, when this is given a value compatible with other experimental and theoretical evidence, reasonably good agreement with experimental results is obtained.

R. C. Binder, USA

1905. Petermann, H., The secondary influence of the clearance loss on radial centrifugal pumps and compressors with cover plate (in German), *ZVDI* **101,** 11, 430–432, Apr. 1959.

The capacity curves and efficiency curves, related to the packing arrangement and widths of packing clearance, were investigated on a single-stage radial flow blower of standard design, with high-duty sealing rings, and a special design with flow-retarding collar. It was proved that the clearance loss in the first place caused a delivery loss and, in the second place, influenced the head. This secondary influence is attributable to the variations in blade losses and reduced impeller performance. It is related to the direction and rate of clearance-loss flow blown into the main flow. The deflecting collar, as opposed to high-duty sealing rings, permits the head to be increased and, at the same time, the blower's total efficiency to be improved.

From author's summary

1906. Turner, R. C., The effect of axial spacing on the surge characteristics of two mismatched axial compressor stages, Aero. Res. Counc. Lond. Curr. Pap. 431, 29 pp., 1959.

Report describes an investigation into two of the major factors governing the surge of multistage axial compressors—the mismatching of the stages and the spacing between them. The purpose is to contribute to a fundamental understanding of surging.

Two highly mismatched stages were tested at five interstage spacings over a wide range of flow coefficient. The results were compared with those of separate tests on each stage. It was found that there was considerable mutual interference as regards the surge behavior, and the aerodynamic characteristics generally were also affected. In particular, at the lower spacings, the second stage considerably delayed the surge of the first.

These results have important implications in the understanding of the mismatched operation of a single multistage compressor and also in the operation of two compressors in series, as in a double compound engine.

From author's summary

1907. Yourinsky, V. T., and Narayanamurthi, R. G., The method of equivalent replacements applied to the investigation of force transfer and power exchange in a stage of a turbomachine, *J. Indian Inst. Sci.* **40,** 1 (Section B), 11–57, Jan. 1958.

1908. Yourinsky, V. T., and Narayanamurthi, R. G., A new form of expression for power on blading in a stage of a turbomachine based on the method of equivalent replacements, *J. Indian Inst. Sci.* **40,** 1 (Section B), 11–57, Jan. 1958.

1909. Likhterov, B. M., Examination of the value of the calculated velocity of the air in axial compressors of transport and gas turbine installations (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 38–46, 1955; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11049.

An attempt is made to work out a method for computing the influence of the value of the calculated velocity of flow of the air on the adiabatic k.p.d. (efficiency) and dimensions of an axial compressor, and also on the number of its revolutions and safety margin over the critical number of revolutions. The investigation is directed mainly to a transport compressor under the following assumptions: (1) the compressor possesses an infinite number of stages; (2) the velocity of the inlet air is equal to zero, while the velocity pressure at the outlet of the compressor dissipates entirely; (3) the (efficiency) k.p.d. of all the stages is identical. Assumptions (1) and (3), in fact, are included in the polytropic efficiency k.p.d. of the compressor or, as it is also called, the efficiency k.p.d. of the process. An analysis is made taking into account the deflection stresses produced by aerodynamic forces. Stresses due to centrifugal forces are disregarded.

Yu. A. Korostelev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1910. Veselov, A. I., Removal of water from deep mine shafts and the problem of manufacturing high pressure and efficient centrifugal pumps (in Russian), *Gornyi Zh.* no. 9, 42–46, 1956; *Ref. Zh. Mekh.* no. 5, 1958, Rev. 5356.

A discussion on the paper by I. M. Zhumakhov [see: *Gornyi Zh.* no. 2, 39–45, 1956] on the shortcomings of existing mining section pumps and on the measures to be taken to raise their efficiency. Author indicates the necessity for utilizing spiral centrifugal pumps in mine shafts; these should have a specific rapid working speed of 100, with symmetrically disposed wheels, efficient supporting bearings, a pressure in the stage of 200 to 300 m, with the number of stages not exceeding four, a high k.p.d. (efficiency) and a capacity up to 200 m^3/hr. The number of revolutions of the pump shaft should not be less than 3000 a minute. After consideration of the positive test for the working of a deep pumping station in the New mine, in the Leningorsk group, author makes proposals to speed up the setting deeper of the water removal apparatus working with a negative height of suction. The necessity was emphasized to maintain constant control over the output of the working pumps. V. N. Gusev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1911. Hasinger, S., A study of the peripheral pump, WADC TR 57-333 (PB 131 363; ASTIA AD 130 845), 64 pp., May 1957.

Paper will interest designers of pumps and research workers. Author's considerations are speculative and are based on assumption of a circulatory flow superimposed on through flow in ring channel (due to impact diffusion) and forced vortex motion in impeller. Theoretical model is not unlike that due to Wilson et alia [AMR **9**(1956), Rev. 1931] but attack is less rigorous. Work would have been more valuable if it had taken this work into account and also that of Senso [AMR **10** (1957), Rev. 523].

Reviewer does not agree that "flow in the ring channel follows free vortex law" (p. 19). Motion of fluid in this zone is rotational. Nevertheless paper is a useful contribution to the difficult problem of establishing a complete theory of the regenerative pump.
R. A. A. Bryant, Australia

1912. Hathaway, C. A., Mixed-flow impellers enter air-moving field, *Prod. Engng.* **30,** 1, 56–59, Jan. 1959.

The mixed-flow impeller out-performs older types where pressures are too high for axial fans and too low for centrifugal blowers. Charts and equations for comparing performance are given. From author's summary

Flow and Flight Test Techniques and Measurements

(See also Revs. 1655, 1832, 1868, 1902, 2003, 2006, 2040)

1913. Short notes contributed to the Pressure Measurements Meeting, sponsored by the AGARD Wind Tunnel and Model Testing Panel, AGARD Rep. 163, 203 pp., Mar. 1958.

1914. Croke, E. J., and Grey, J., Determination of transient pressure flow relationship by momentum measurements, *ARS J.* **29,** 3, 213–214 (Tech. Notes), Mar. 1959.

A momentum-sensitive device was used to measure the transient flow rate through a rocket motor injector. The relationship between instantaneous pressure drop and flow rate was measured under conditions of artificially induced small sinusoidal oscillations at various frequencies. The observed phase shift of flow rate behind pressure drop agreed quite well with previous theoretical predictions, but some discrepancy was observed between the predicted and observed amplitude ratios.
From authors' summary

1915. Gilbrech, D. A., An electro-mechanical transducer for measuring dynamic pressures in fluids, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 320–330.

1916. Ibrahim, A. A. K., A method for measuring the dynamic viscosity and dynamic rigidity of visco-elastic liquids, Part II, *Acta Phys., Acad. Sci. Hungaricae* **10,** 1, 111–114, 1959.

See AMR **12**(1958), Rev. 1445.

1917. Prados, J. W., and Peebles, F. N., Two-dimensional laminar-flow analysis, utilizing a doubly refracting liquid, *AIChE J.* **5,** 2, 225–234, June 1959.

Paper makes a valuable contribution to the problem of how to derive quantitative results for the velocity distribution from the visible interference patterns, obtained when a doubly refracting liquid flows through a transparent channel between polarizing plates. This technique, analogous to the photoelastic technique for stress analysis, is applied to three types of two-dimensional laminar flow: (a) flow between parallel plates; (b) flow in convergent and divergent channels; (c) flow about a cylindrical obstacle.

Where possible, the quantitative results, calculated from the interference patterns, are compared with independent experimental results. The agreement is promising. H. Bergh, Holland

1918. Wardlaw, R. L., and McEachern, N. V., A wing-submerged lifting fan: wind tunnel investigations and analysis of transition performance, Nat. Res. Counc., Canada, Aero Rep. LR-243, 72 pp., Apr. 1959.

Wind-tunnel force measurements have been carried out on a wing-fan combination; the high solidity fan was embedded in a two-dimensional symmetrical wing, with the fan axis normal to the wing chord-plane.

Results are discussed and compared with a simple momentum theory, with a view to their usefulness in VTOL project studies. Over a limited range, fan power and model force measurements provide reasonable correlation with theoretical predictions.

An understanding of the flow in the vicinity of the fan is facilitated by surface pressure measurements and water-tunnel flow-visualization studies. From authors' summary

1919. Wittliff, C. E., Wilson, M. R., and Hertzberg, A., The tailored-interface hypersonic shock tunnel, *J. Aero/Space Sci.* **26,** 4, 219–228, Apr. 1959.

The tailored-interface hypersonic shock tunnel makes use of the properties of the refraction of a shock wave at a contact surface in order to increase the test time by very significant factors. This type of hypersonic shock tunnel relies on the main shock wave that is reflected from the end of the driver section of a shock tube to produce a stagnation reservoir of uniform hot gas which is then expanded through a hypersonic nozzle. The uniformity of this gas can be maintained for a longer duration provided the thermodynamic conditions across the natural contact front produced by rupturing the diaphragm in a shock tube are matched or tailored to give a reflected Mach wave when the main shock wave reflected from the end of the tube refracts at this contact front.

A solution to this problem can be given in closed form for the case of a perfect gas (see "An experimental study of shock-wave refraction," by C. A. Ford and I. I. Glass, UTIA Rep. no. 29, 1954). In the case of an imperfect gas the matching condition for a reflected Mach wave must be found in a step-by-step manner. The authors present such solutions in graphical form for the case of hydrogen and helium as the driver gases and air as the reservoir gas.

The maximum testing time after the shock refraction is limited

by the arrival of the tail of the rarefaction wave at the natural contact front. Additional significant improvement in test time can be obtained by using a variable area Laval-type nozzle at the diaphragm station. As a result, it is theoretically possible to obtain an overall gain from 14 to 60 times the test time, depending on the shock Mach number, that can be achieved with a conventional nonreflected-type shock tunnel of the same length (without the diaphragm nozzle the gain factor is from 8 to 12). The total test time is a decreasing function of the shock Mach number.

Authors give a worthwhile discussion of the effects on the flow resulting from shock-boundary layer interactions, contact front mixing, radiation losses, nozzle heat transfer, thermodynamic nonequilibrium and flow development time over models.

The paper includes a description of the Cornell Aeronautical Laboratory 11-in. × 15-in. hypersonic shock tunnel and the results of flow measurements using heat-transfer gages, piezo pressure gages and multiple-spark schlieren photographs. Results are presented to show that the tailoring method is a successful and practical technique and that a calibration of the test section can be obtained on the basis of certain assumptions (isentropic and equilibrium flow). These results are substantiated by heat-transfer measurements over a hemisphere at nominal stagnation temperatures of 2000 to 6000 K, which also agree with theoretical predictions.

Reviewer recommends this paper to those interested in nonstationary gas-dynamics, hypersonic flows, and shock-tunnel instrumentation and testing. I. I. Glass, Canada

Thermodynamics

(See also Revs. 1726, 1837, 1849, 1902, 1983, 2011, 2019, 2056, 2063)

1920. Martin, J. J., Kapoor, R. M., and DeNevers, N., An improved equation of state for gases, *AIChE J.* **5,** 2, 159–160, June 1959.

A discussion is presented of a modified equation of state for gases and of evaluation of its parameters. A relatively good fit to experimental data for carbon dioxide is demonstrated, with improvement over earlier methods particularly in the region of 1.4 times the critical density. E. W. Price, USA

1921. Arave, R. J., Concise, systematic Jacobian thermodynamics for high-temperature real gases, *J. Aero/Space Sci.* **26,** 4, 250–253 (Readers' Forum), Apr. 1959.

Jacobian tables are presented for obtaining thermodynamic partial derivatives of gases with and without dissociation and ionization. The tables are a useful short-cut procedure for showing the relationships between various thermodynamic partial derivatives. M. Gerstein, USA

1922. Bade, W. L., Simple analytical approximation to the equation of state of dissociated air, *ARS J.* **29,** 4, 298–299 (Tech. Notes), Apr. 1959.

1923. Logan, J. G., and Colichman, E. L., Effect of dissociation on the performance of working fluids for nuclear propulsion, *ARS J.* **29,** 6, 409–413, June 1959.

Recent developments indicate a growing interest in nuclear propulsion. In this paper, general enthalpy relations are derived for an idealized diatomic gas to investigate the effect of molecular weight, dissociation energy and pressure on the performance of diatomic working fluids. It is shown that maximum performance for a given molecular weight should be obtainable from molecules with bond energies in the range 1.5 to 2.5 ev. The influence of pressure on dissociation is also indicated. The results of the study for the diatomic system also indicate desirable ranges of molecular weight and bond energy for more complex molecular systems. From authors' summary

1924. Van Ness, H. C., and Mrazek, R. V., Treatment of thermodynamic data for homogeneous binary systems, *AIChE J.* **5,** 2, 209–212, June 1959.

A graphical procedure for determining partial molal quantities is presented which is more accurate than the usual tangent intercept method. A number of tests, some of them new, for checking thermodynamic consistency based on the Gibbs-Duhem equations are presented. A. Sesonske, USA

1925. Brice, D. B., and Fishman, N., Some physical properties for the system nitrogen tetroxide-nitric oxide, *ARS J.* **29,** 5, 354–357, May 1959.

Mixed oxides of nitrogen may become an important oxidizer with the advent of storable, pre-packaged, liquid propellant rocket engines. This paper presents some physical property data for the liquid system nitrogen tetroxide-nitric oxide at temperatures between zero and minus 100 F. Properties included are vapor pressure, density, viscosity and surface tension. From author's summary

Book—1926. Gajczak, S., Absorption refrigeration [Absorpcyjne urzadzenia chlodnicze], Warszawa, Panstwowe Wydawnictwa Techniczne, 1958, 167 pp. zl. 21. (Paperbound)

This monograph is designed as both a text for mechanical engineering students and a reference for practicing engineers. As such it provides a very thorough treatment of the thermodynamics of binary solutions with particular reference to absorption and desorption processes, together with a summary of engineering design data, thermodynamic properties of most important solutes and solutions and design procedures as well as descriptions of typical installations.

The first three chapters discuss the basic principles and give a very detailed thermodynamic analysis of each of the elements of an absorption installation, such as the absorber, generator, rectifier, etc. Graphical methods of analysis and off-design performance calculations are stressed. Chapter 4 describes the analysis of complete refrigeration plants from the simplest to those including multiple rectification columns and numerous regenerative heat exchangers. Chapter 5 deals with the properties of principal binary systems used in absorption and adsorption refrigeration, while Chapter 6 describes in detail some typical installations. Particularly useful is the description and comparison of various automatic control systems.

The text draws on American, European and Russian literature and nearly 100 references are listed, up to 1956. There are 14 problems, some quite comprehensive, with answers. To reviewer's knowledge, no text of comparable scope exists in the English literature. J. R. Moszynski, USA

1927. Chiang, S. H., and Toor, H. L., Interfacial resistance in the absorption of oxygen by water, *AIChE J.* **5,** 2, 165–168, June 1959.

Transient absorption rates of oxygen into water have been measured by passing a laminar jet through the pure gas for contact times varying from 0.8 to 11.8 msec. The absorption rate is significantly lower than the theoretical value corresponding to no interfacial resistance, if a diffusivity of 2.20×10^{-5} sq cm/sec at 22.2 C is used for comparison. The available evidence indicates that this diffusivity is about correct and that the lowered rate may be caused by an interfacial resistance described by an interfacial transfer coefficient equal to 0.6 cm/sec. This resistance is small enough to be neglected in most gas absorbers. From authors' summary

1928. Kapitsa, P. L., Design of a helium-liquefying cycle with expansion engines connected in cascade, *Soviet Phys.—Tech. Phys.* **4,** 4, 377–382, Oct. 1959. (Translation of *Zh. Tekh. Fiz.* **29,** 4, 425–427, Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The problem of the most effective cascade connection of expansion engines in a cyrogenic cycle is solved. General expressions are derived for the determination of the temperature levels at which the expansion engines operate effectively. It is shown that if the efficiencies of the expansion engines differ only slightly, the most favorable conditions of operation are those in which the same amount of gas enters each of the engines. An expression is derived for determining the optimum number of expansion engines in a cycle. A quantitative analysis is made of a cycle for cooling a stream of helium from room temperature to a temperature close to that at which it liquefies.

From author's summary by P. W. Whitton, England

1929. Jacobs, R. B., Recent advances in cryogenic engineering, *ARS J.* **29,** 4, 245–251, Apr. 1959.

1930. Swanson, B. W., and Somers, E. V., Optimization of a conventional-fuel-fired thermoelectric generator, *ASME Trans.* **81** C (*J. Heat Transfer*), **3,** 245–248, Aug. 1959.

This analytical study involves the direct production of electrical energy in a thermoelectric generator duct. The heat source is the heated gas flowing in the center of the duct and the heat sink, the flow of a fluid in the coolant jacket. The separating partition consists of thermocouple elements connected in series. Equations are developed for (1) The temperature distribution of the heated gas in a circular duct type of generator, that maximizes the thermoelectric power output with respect to the temperature distribution with the duct and the exit gas temperature at the end of the duct; (2) The thermoelectric power developed, based upon these optimizing temperature criteria; (3) The required variation of thermoelectric element thickness required to satisfy both optimizing temperature criteria; (4) Thermal efficiency under optimum conditions.

G. A. Hawkins, USA

1931. Geballe, T. H., Radiation effects in semiconductors: thermal conductivity and thermoelectric power, *J. Appl. Phys.* **30,** 8, 1153–1157, Aug. 1959.

The use of thermal conduction and thermoelectric measurements in studying radiation damage effects in semiconductors is discussed. The conclusion is reached that in the present state of knowledge such measurements will probably be more helpful in studying the kinetics of the formation and annealing of radiation-introduced defects than in characterizing the structure of such defects.

From author's summary

1932. Ihnat, M. E., and Hagel, W. C., A thermocouple system for measuring turbine-inlet temperatures, ASME Instruments and Regulators Conf., Cleveland, Ohio, Mar.–Apr. 1959. Pap. 59-IRD-1, 6 pp.

1933. Suzuki, S., A method of measuring actual amount of rate of percolation, specific heat and heat conductivity of soil, *Geophys. Mag., Tokyo* **28,** 4, 499–503, Sept. 1958.

The soil temperatures in a rice paddy field through which water is percolating are determined analytically as a function of depth and time for the case where the surface temperature varies sinusoidally. The solution is essentially that for a semi-infinite solid with additional terms which consider the enthalpy associated with the water flow:

$$\theta = \theta_0 e^{-az} \sin\left(\frac{2\pi}{T}t + bz\right)$$

where $a = \left(\frac{\pi\rho c}{Tk}\right)^{1/2} - \frac{v}{2k}$

$$b = \left(\frac{\pi\rho c}{Tk}\right)^{1/2}$$

T = period of oscillation of surface temperature

v = percolation velocity

The solution is valid only for very low velocities v such that $v \ll \frac{2\pi}{T} k\rho c^{1/2}$. By measurement of the variation of temperature at a given depth and known properties of the soil, the percolation velocity can be calculated.

H. Merte, Jr., USA

1934. Jaswon, M. A., The thermodynamic behaviour of solids, *Research Lond.* **12,** 7, 274–284, July 1959.

Paper provides an outline of the main principles of thermodynamics, particularly in relation to the light they throw on the behaviour of solids.

From author's summary

1935. Zaitseva, L. S., An experimental investigation of the heat conductivity of monatomic gases over wide temperature intervals, *Soviet Phys.-Tech. Phys.* **4,** 4, 444–450, Oct. 1959. (Translation of *Zh. Tekh. Fiz.* **29,** 4, 497–506, Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

Experimental data of thermal conductivity λ are presented for the monatomic gases He, A, Ne, Kr, Xe and Hg vapor over a temperature range from about 300 to 800 K. The data are obtained by using the hot-wire method for measuring the heat transfer to a thin conducting wire of 0.1-mm diameter. Measurements of all gases were conducted at various pressures P, ranging from about 20 to a few hundred mm of Hg. Errors due to the temperature jump between wire and gas were eliminated by extrapolating to a temperature difference Δt at higher pressures from a linear plot of the measured Δt as function of $1/P$.

The data indicate that the ratio $\varepsilon = \lambda/\eta C_v$ (η = viscosity, C_v = specific heat at constant volume) increases with temperature T, and also with molecular weight M for any constant temperature. For the above-mentioned monatomic gases and temperature range the ratio ε was found to vary from about 2.45 to 2.75, which is about a 10% variation from the classical value of 2.5 for monatomic gases. The author established an empirical relation for $\varepsilon = f(MT)$ which corresponds to a theoretical equation of Euskog, but found that the increase of ε with T was greater than predicted by Euskog's theoretical equation. The viscosity data were taken from the available literature. Reference is made to "Aiken", which should read "Eucken."

Ruth N. Weltmann, USA

1936. Donaldson, I. G., Temperature errors introduced by temperature-measuring probes, *Brit. J. Appl. Phys.* **10,** 6, 252–255, June 1959.

A cylindrical probe is approximated by a prolate ellipsoid. Laplace's equation is applied assuming the heat flow in the surrounding medium to be along the long axis of the probe. The percentage of error is shown to be related to the ratio of thermal conductivities, and to the ratio of length to radius. Metal probes used to measure the temperature of hot ground introduce considerable errors. Author suggests use of probes of thermal conductivity equal to that of the hot ground.

Applications are related to heat-flow measurements in thermal region in New Zealand.

G. Miskolczy, USA

Heat and Mass Transfer

(See also Revs. 1594, 1599, 1600, 1747, 1800, 1825, 1860, 1865, 1869, 1874, 1919, 1926, 1932, 1933, 1935, 1936, 1992, 1996, 1997, 2018, 2019)

Book—1937. Eckert, E., Introduction to heat and mass transfer, 2nd ed. **[Einfuhrung in den Warme- und Stoffaustausch,** Zweite Auflage], Berlin, Springer-Verlag, 1959, x + 295 pp. DM 28.80.

First edition (1949) is revised extensively to provide an authoritative text on principles of conduction, convection, and radiation heat transfer, and on principles of mass transfer, including many developments of the past decade. A clear treatment of the several physical processes, rather than a collection of empirical relations and literature titles, is emphasized.

Author is Professor and Director of the Heat Transfer Laboratory, University of Minnesota, has been a leader in heat-transfer research for many years, and is especially familiar with heat-transfer activities in Germany and the United States, having worked in both countries. In recognition of his many contributions, the ratio $u_\infty^2/c_p(T_w - T_\infty)$ has been called by Schlichting [AMR **9** (1956), Rev. 215] the Eckert number.

Comparing this edition with the first edition, material on the relaxation method and on melting and freezing has been added to the section on conduction. The section on convection contains new material on convective heat transfers along nonisothermal surfaces, in corners, at high speeds, in liquid metals, in rarefied gases, and in film- and sweat-cooling systems. New topics in the section on radiation include pyrometry, solar radiation, and the solution of radiation problems using electrical analogs. Material carried over from the first edition (including the section on mass transfer) has been rewritten to include recent advances. The International System of units is used with the exception that force is given in kiloponds instead of in Newtons, where one kilopond is the force required to give an acceleration of 9.80665 meters per second per second to a mass of one kilogram.

The reviewed book (suitable for use as an introductory textbook) and the book *Grundgesetze der Wärmeübertragung* by Gröber, Erk, and Grigull [AMR **9** (1956), Rev. 886; more suitable for use as a reference book] are complementary. The reviewed book and the book "Heat and mass transfer" by Eckert and Drake (New York, McGraw-Hill, 1959) are similar; the reviewed book is more brief (especially the section dealing with heat conduction) and does not contain the chapter dealing with heat-exchanger calculations.

Reviewer has relatively few criticisms of book, but believes that a title hinting that the section on mass transfer is a small fraction (10%) of the book would be appropriate. The persistence of established scientific literature is observed once again; the original Eucken approximation for the thermal conductivity of a polyatomic gas is used in spite of evidence [*J. Chem. Phys.* **26,** 282–285, Feb. 1957, and *Jet Propulsion* **27,** 1262–1263, Dec. 1957] indicating that a simple modification of the original approximation fits better the available data. Printing and binding are of high quality. Reviewer noted only a few typographical errors, the most serious being perhaps the printing upside-down of Figure 112.

In summary, this book provides an up-to-date treatment, by a leading researcher in the field, of the fundamental principles of heat transfer, emphasizing clear descriptions of the physical processes, and suitable for use as an introductory textbook at the senior or first-year graduate level.

E. L. Knuth, USA

1938. Lapides, M. E., and Goldstein, M. B., Heat transfer source file data, General Electric Co., Atomic Products Div., Aircraft Nuclear Propulsion Dept., APEX 425, Nov. 1958.

This report, a part of a source file of heat-transfer data for design problems encountered in the Aircraft Nuclear Propulsion Department, deals with turbulent flow of gases in various types of ducts. The following items are discussed: heat flux and mode of heat input effects, entrance region effects, duct cross-section effects, annular passages, heat transfer momentum analogies, and recommendations of analytical methods used on the duct configurations considered.

Although the primary purpose of this report is to summarize available data and provide working correlations, considerable effort is devoted to theoretical interpretations. A narrative rather than a mathematical approach is employed.

From authors' summary

1939. Granet, I., An approach to the calculation of the temperature distribution in cylindrical reactor vessels, *J. Amer. Soc. Nav. Engrs.* **71,** 3, 465–470, Aug. 1959.

In designing of pressure vessels for use in nuclear plants, the designer has to investigate stresses due to pressure and external loads on the one hand and stresses caused by internal heat generation on the other. As to temperature stresses, only certain of all the nuclear processes are of interest.

To calculate the (steady-state) temperature distribution, due to the internal heat-generation, in a cylindrical vessel with internal radius R_i, external radius R_0, the author assumes that the curve of heat production is of exponential type (in R) and the curve $t(R)$ of the temperature distribution has a maximum value t_m for a certain R_m. Applying Fourier's law, integrating and using the boundary values for t, he gets the function $t(R)$.

The second method used lies in integrating an ordinary differential equation of second order with prescribed boundary conditions. The solution is obtained by use of a suitable transformation and variation of parameters.

There are some small mistakes in the work: The upper limit R in Eq. [10] is to be replaced by R_0; Eq. [15] is not nonlinear, only with nonconstant coefficients; for this equation we need not use reference (3), this equation follows by differentiating [1].

Also, it is not evident how to determine t_m and R_m in the case of the first method used.

K. Rektorys, Czechoslovakia

1940. Thomsen, J. S., Physical interpretation of the relaxation method in heat conduction, *AIChE J.* **5,** 2, 268–269 (Communications to the Editor), June 1959.

Author uses Prigogine's theorem on the minimum production of entropy to show that the relaxation method for the numerical solution of the heat-conduction equation must converge to give an exact solution of the difference equations.

E. H. Wissler, USA

1941. Dart, D. M., Effect of fin bond on heat transfer, *ASHRAE J.* **1,** 5, 67–71, May 1959.

1942. Baxter, D. C., The freezing and melting times of slabs and cylinders, Nat. Res. Counc. Canada, Div. Mech. Engng. Rep. MK–1, 42 pp., Feb. 1959.

Report describes analog solutions of heat-conduction equation involving change of state, using PACE analog computer. By introducing new dependent variables, namely "enthalpy" and "flow temperature" (reviewer noted that the latter is identical to the transformation first suggested by Elrod), a single equation is applicable to both liquid and solid regions in problems dealing with melting or solidification. In this respect the method differs from the usual procedure of treating the two regions separately. It is therefore more direct and the computation is more convenient.

Generalized results of fusion or freezing times for slabs and long cylinders of a pure substance, initially at fusion temperature and exposed to an ambient fluid of constant temperature with infinite and finite surface conductances, are presented in graphical form. Interpolation formulas are also given. Error in the computed results for the six-lump model used in the analysis is estimated to be 2%.

B. T. Chao, USA

1943. Green, L., Jr., Heat transfer in a power-producing porous solid, Proc. Third U. S. Nat. Congr. Appl. Mech., June 1958; Amer. Soc. Mech. Engrs., 1958, 747–751.

This paper presents a one-dimensional analysis of the steady-state temperature distribution in a gas-cooled, heat-generating porous solid. Author presents an argument why it is preferable to use a steady-state technique for determining heat-transfer coefficients in consolidated media rather than a transient method. He describes an experiment in which the specimen consisted of a resistance-heated, thin-walled cylinder of commercial porous graphite, shielded to minimize radiation losses to the surrounding container. The analysis, which assumes the existence of a finite coefficient of heat transfer between the solid and gas phases, permits an average heat-transfer coefficient to be determined from steady-state experiments in which precise measurements of gas temperature at the entrance and exit faces of the solid are not required if the temperatures of the porous surfaces are known. Author also presents the limiting case of very high heat-transfer coefficients and shows that the analytical results are in agreement with those of a previous analysis in which the solid and gas temperatures within the porous structure were assumed to be substantially equal. J. S. Aronofsky, USA

1944. Yang, K.-T., Unsteady laminar boundary layers over an arbitrary cylinder with heat transfer in an incompressible flow, *ASME Trans.* **81**E (*J. Appl. Mech.*) 2, 171–178, June 1959.

An analysis is made of the flow and heat-transfer response to an unsteady free-stream velocity. Both the surface temperature and the free-stream temperature are unchanging with time and position. The analytical procedure is an extension of the author's previous paper [*J. Appl. Mech.* **25,** 421–427, 1958] on the unsteady flow and heat transfer at a stagnation point. There, exact solutions were obtained for a free-stream velocity u_∞ of the form: $u_\infty \sim x/(1 - \alpha t)$, where α is a parameter. Using universal functions from these solutions, an approximate calculation procedure was proposed to permit arbitrary time variations in free-stream velocity. In the present paper, a further generalization in the approximate procedure is made to permit an arbitrary dependence of the free-stream velocity on position as well as on time.

E. M. Sparrow, USA

1945. Bertram, M. H., and Feller, W. V., A simple method for determining heat transfer, skin friction, and boundary-layer thickness for hypersonic laminar boundary-layer flows in a pressure gradient, NASA Memo 5-24-59L, 60 pp., June 1959.

By a similarity analysis the boundary-layer parameters in a hypersonic flow with Prandtl number unity and a pressure gradient proportional to a power of the streamwise coordinate are related to the corresponding values for the flat plate. A table of parameters required for the method is compiled from previous numerical solutions of the boundary-layer equations.

It is shown that the strong interaction solution for the self-induced pressure gradient on a flat plate is a particular case of present method. Experimental data on blunt-nosed flat plates and cylinders at Mach numbers from 4 to 6.8 and angles of attack from 10° were correlated by the analysis. However, because the effect of pressure gradient is smaller than the effect of local conditions, the validity of the application to blunt bodies is not severely tested by this comparison. W. Squire, USA

1946. Davies, T. V., On the forced motion due to heating of a deep rotating liquid in an annulus, *J. Fluid Mech.* **5,** 4, 593–621, May 1959.

The fluid is confined between two vertical concentric cylinders and is rotating bodily. The flow is assumed approximately horizontal along the isobars, and the pressure hydrostatic. A transfer of heat from one wall to the other is made possible by means of a molecular thermal conductivity. The heat flux across the boundary is assumed to be the same at all points of it. Molecular viscosity is ignored, which casts serious doubt on the physical relevance of the solutions obtained. The depth is assumed large compared with the horizontal dimension, so that vertical conduction of heat is neglected.

The equations of motion are, with these approximations, arranged to relate pressure and temperature only, and the solution is assumed to be of the form of waves of period $2\pi/m$ in θ, the "longitude." On substitution in the equations the terms in $2m\theta$ are assumed to vanish and on separation into functions of r and θ, five equations are found. These have exact solutions which do not apply if the fluid is viscous. This is most interesting and the author claims that light is thrown on the form of the wave with amplitude.

No solution exists if the inner radius is smaller than a particular value, but the author's conclusion that this means that no steady flow of this form can occur in an open dishpan is to be questioned because of the restrictive assumptions. One may question the results obtained when a transfer of momentum from one cylinder to the other is assumed to take place, because, having no viscosity, the fluid cannot impart momentum to the walls. It is not surprising that the model can transfer heat without momentum.

It is claimed that the results throw light on the stability diagram which Fultz obtained experimentally.

By means of higher-order approximations some idea of the vertical velocity is obtained, but the elegant mathematics is not matched by interpretation of what the results mean. It is not sufficient to draw attention to similarities with properties of the atmosphere already well-known when the physical differences between the atmosphere and the model are not discussed. No interpretation is given of the conclusion that when the inner cylinder shrinks to nothing "no continuous non-zero solution exists."

R. S. Scorer, England

1947. Yang, H.-T., Second approximations for the stress tensor and the heat flux in a gas, *Physics of Fluids* **2,** 2, 237–238 (Letters to the Editor), Mar.–Apr. 1959.

1948. Selin, G., Determination of surface temperature in heat transfer (in Swedish), *Tekn. Tidskr.* **89,** 11, 251–254, Mar. 1959.

1949. Hunziker, R. R., Heat transfer and Reynolds analogy in a turbulent flow with heat release (in English), *ZAMP* **9a,** 4, 307–315, Nov. 1958.

Pai's polynomial solutions of the Reynolds turbulent flow equations for a circular pipe are used in an extension of the Reynolds analogy of heat and momentum transfer to the case where heat sources are present in the fluid. The boundary-value problem is formulated and solved for the case where the temperature of the fluid at the pipe wall is changed suddenly at a certain cross section. Axial heat conduction is neglected. Comparison of the equations and boundary conditions with those for the case with no sources present leads to a theorem giving the asymptotic distribution of temperature in the pipe in terms of Pai's polynomials when the Prandtl number is equal to the empirical ratio of eddy diffusivities of momentum and heat.

R. P. Pearce, Scotland

1950. Grodzovskii, G. L., Some exact solutions of the problem of gas flow in a tube taking into account friction and convective heat exchange (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 127–129, Aug. 1958.

This is a study of one-dimensional, constant-area flow of a viscous, heat-conducting, compressible fluid. The basic relations are similar to those given by Shapiro ["The dynamics and thermodynamics of compressible fluid flow," Chapter 8] except that the independent variable is v/a^* rather than Mach number. The general analysis follows Shapiro's Section 8.9 quite closely; however, the final equation is essentially velocity as a function of length with wall temperature as a parameter. The exact solutions

are found by assuming a temperature-velocity relation which will allow exact integration of the differential equation. These exact solutions are then discussed in terms of the flow processes. It is shown that the constant wall temperature solution is in good agreement with experimental data.

Reviewer believes that the primary use of these results will be as reference solutions for approximate analyses.

E. E. Covert, USA

1951. Mezhirov, I. I., On gas flow in a cylindrical tube in the presence of friction and heat transfer (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 118–120, Sept. 1958.

The purpose of this paper is to present further results on heat transfer from a tube. Author observes that frequently the exact solutions (cf preceding review) are not generally applicable to practical situations. Since, over short elements of a tube, most of the variables change slowly, the equations can be integrated and put in a difference form for machine calculations. Author observes also that a general integral exists for the energy equation if the Reynolds analogy is used.

Reviewer is of the opinion that the main contribution in this article is contained in the forward differencing procedure. This procedure is probably superior to trapezoidal integration for hand computation but is not well suited to automatic computation.

E. E. Covert, USA

1952. Filippova, L. A., Plane unsteady motion of a viscous incompressible liquid with heat exchange in operation (in Russian), *Vestn. Leningrad In-ta* no. 1, 141–151, 210–211, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12694.

An investigation is made of an irregular laminar flow of a viscous incompressible liquid in a narrow slit of constant width with heat exchange operating in the walls surrounding this liquid. The equations of motion and heat conductivity are solved with the following accepted assumptions: the motion of the liquid takes place in the unbounded plane slit, the upper wall of which is fixed while the lower begins to move from a state of rest along the axis OX at a given velocity $u(t)$. No account is taken of the action of mass forces and of the changes in temperature of the liquid along axis OX. In addition, it is assumed that the heat exchange with the surrounding medium proceeds in accordance with Fourier's principle. With these assumptions in force the author finds a solution for a system of equations of motion and heat transfer in the form of infinite series. The solution found enables a determination to be made of the profile of temperatures on the slit's section for any moment of time, provided the heat transfer on the walls is known in the initial moment of time. It is noted that the solutions obtained can be extended to embrace the case of a flow in an annular orifice formed by two coaxial cylinders, provided that the width of the annular clearance is small by comparison with the radius of the cylinders and that the outer cylinder is immovable, while the inner cylinder in the initial moment of time starts moving at the given velocity $u(t)$.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1953. Yushin, A. Ya., Experimental investigation of local heat convection in a mixed motion of liquid in a round tube (in Russian), *Sb. Statei Nauchn. Stud. O-va Mosk. Energ. In-ta* no. 10, 164–177, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11249.

Paper deals with the investigation of local heat emission in the first portion of a tube when the tube contains portions with laminar, transitional and turbulent flows. Tests for heat emission preceded a visual investigation on a Reynolds apparatus of the phenomenon of change of the laminar to the turbulent regime during isothermal flow of the liquid in the tube. The observations show that the location of the point of change depends essentially on the number R_D and the conditions at the inlet to the tube; in a tube with a sharp inlet the transition takes place much earlier than in a more open inlet. The investigation of heat emission was carried out by the method of the thick-walled tube perfected by B. S. Petukhov. The number R_D changed from 3000 to 12,000 during the investigation period. With open entry to the tube the distribution of the local number N_D along the length of the tube indicates a clearly expressed minimum, corresponding to the beginning of the transit zone, when its position is determined by a well-defined number $R_{xkp} = 52{,}000$. This result is in full agreement with analogous tests carried out by Petukhov and Krasnoshchekov. Six tests were carried out with a narrow inlet to the tube, the results of which were recorded in graph form. These tests show that the heat emission, other conditions being equal, depends essentially on the form of the inlet. With a narrow inlet the local values of N_D in the first portion of the tube are significantly higher than with an open inlet; however in the main part of the tube the values practically coincide.

V. V. Kirillov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1954. Fedorko, P. P., Convective heat exchange and resistance during motion of air in short tubes at low Reynolds numbers (in Russian), *Trudi Leningrad In-ta Inzh. Vodn. Transp.* no. 24, 162–174, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11251.

This is an experimental investigation of convective heat exchange and of resistance in the initial portion when hot air flows through a round tube. The temperature of flow on entry varied from 200 to 500°, the temperature of the wall of the tube was kept constant along its length and equal to 100°; the inlet into the tube was narrow, the inner surface of the tube technically smooth, the relative length of the tube was equal to approximately 40 calibers. The experimental values of the coefficient of resistance are given and also the velocity and temperature profiles for iso- and nonisothermic flows of the air, and the dependence of Nusselt number on Reynolds number. In the conditions of the experiment, in consequence of currents of the free motion, the flow developed turbulence at Reynolds numbers less than 10,000. With nonisothermic flow of the air the length of the initial hydrodynamic portion did not exceed 20 calibers, while the length of the initial thermal portion fell into the limits of 10–16 calibers in relation to Reynolds number. In order to carry out the calculations for a heat-exchanger with short tubes, data were obtained for the determination of the mean coefficient of heat emission from the initial portion at different values for Reynolds number and of the temperature of the air on entry.

A. A. Bodzholyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1955. Zysina-Molozhen, L. M., Some problems of resistance and heat exchange at the under-critical flow (in Russian), Avtoref. Diss. Dokt. Fiz.-Matem. Nauk Leningrad, Politekhn. In-ta Leningrad, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 820.

1956. Eckert, E. R. G., Irvine, T. F., Jr., and Yen, J. T., Local laminar heat transfer in wedge-shaped passages, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57–A–133, 6 pp.

1957. Ostrach, S., and Thornton, P. R., Compressible laminar flow and heat transfer about a rotating isothermal disk, *NACA TN* 4320, 18 pp., Aug. 1958.

A solution of the equations of conservation of mass, momentum, and energy for an axially symmetric, compressible, viscous flow is presented. Viscous dissipation is neglected in the energy equation. The radial and circumferential components of the velocity are assumed to be given by the radius times functions of the normal distance from the disk, and the component of the ve-

locity normal to the disk is assumed to be a function of the normal coordinate alone. The pressure, density, and the temperature ratio between the isothermal disk and the fluid are taken to be functions of the normal distance, and the viscosity and thermal conductivity of the fluid are assumed to depend linearly on the temperature. With these assumptions and the further restriction that the local Mach number at the disk divided by the temperature ratio be small, the authors reduce the partial differential equations of fluid dynamics to ordinary differential equations. The compressible problem is reduced to the incompressible flow problem of von Karman by a suitable change of the independent variable. The effect of compressibility appears as a distortion of both the normal coordinate and the normal velocity component.

Authors properly point out that the problem is essentially a constant pressure process rather than a constant volume process as assumed by Millsaps and Pohlhausen [AMR 5 (1952), Rev. 2871]. This implies that the substantial derivative of the pressure can be neglected in the energy equation while the divergence of the velocity should not be. Neglecting viscous dissipation, the energy equation used by the authors is the same as that used by Millsaps and Pohlhausen except that the coefficient of the substantial derivative of the temperature is the specific heat at constant pressure rather than the specific heat at constant volume.

The results of the numerical integration of the equations of motion are presented in both graphical and tabular form. Good agreement is obtained between calculated and experimental results.

F. H. Abernathy, USA

1958. Jacob, A., and Osberg, G. L., Effect of gas thermal conductivity on local heat transfer in a fluidized bed, *Canad. J. Chem. Engng.* **25,** 1, 5–9, June 1957.

1959. Vandrey, J. F., Upper bounds and conservative estimates for aerodynamic heating at great altitudes, *Jet Propulsion* **27,** 5, 522–526, May 1957.

1960. Barrow, H., Fluid flow and heat transfer in an annulus with a heated core tube, *Instn. Mech. Engrs. Proc.* **169,** 56, 1113–1124, 1955.

1961. Sevruk, I. G., Transient heat convection within a spherical film, *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*) **22,** 3, 587–593, 1958. (Pergamon Press, 122 E. 55th St., New York, N. Y.)

The transient laminar heat convection in fluid confined within a space bounded by two concentric spheres, with the initial conditions that the fluid is at rest and of a uniform temperature and that the wall temperature is at a lower value, is studied by the perturbation technique. Expressing the solution as a power series of Rayleigh number, the zeroth and first-order temperature are obtained in series form.

Author concludes that convection has an almost negligible effect when compared to the heat transfer of the fluid.

L. N. Tao, USA

1962. Motovilovets, I. A., A non-stationary heat convection in the sloping cylinder of finite length (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk Kievsk. In-ta, Kiev, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 822.

1963. Tetyuev, V. A., Experimental investigations of free heat convection in water filling an inclined cylinder (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk Molotovsk. In-ta, Molotov, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 821.

1964. Laird, A. M., Scott, A. W., and Thomson, A. S. T., Natural circulation investigations on an experimental two-tube boiler, *N. E. Coast Instn. Engrs. Ship. Trans.* **74,** 6, 311–340, Mar./Apr. 1958.

1965. Hermann, R., Leitinger, H., and Melnik, W. L., The high temperature heater and evaporative film cooling of nozzle throat sections of the Rosemount Aeronautical Laboratories' hypersonic facility, WADC TR 58-376 (OTS 151487; ASTIA AD 204 663), 50 pp., July 1958.

A gas-fired storage heater to heat the supply air for the 12-inch × 12-inch hypersonic wind tunnel at Rosemount Aeronautical Laboratories was designed, manufactured, and installed. Preliminary firing tests have been conducted with this heater.

An experimental investigation on evaporative film cooling of hypersonic nozzle throat sections was conducted in the same wind tunnel. Coolant (water) was injected through a thin strip of porous metal located upstream of the throat where the average Mach number was 0.08. The object of this investigation was to determine the influence of evaporative film cooling on the nozzle flow. Two configurations have been investigated with 15° and 30° expansion angle.

The results are as follows:

For the 15° configuration, measurements were made at a station where $M = 4.73$. For $T_0 = 682°R$ there was a 0.63% decrease in Mach number with the presence of coolant flow as compared to dry flow. The introduction of evaporative film cooling increased the velocity boundary-layer thickness approximately 56% at the survey station; however, no change was detected in the thickness of the thermal boundary layer. The coolant film was observed to be uniform and attached throughout the nozzle.

For the 30° configuration, the investigation was conducted at a station where $M = 5.71$. Flow observations revealed that the liquid film was attached to the nozzle wall up to the separation point of the air flow. Lack of funds prevented further continuation of the investigation on the 30° throat model configuration.

From authors' summary

1966. Sutton, G. W., Adiabatic wall temperature due to mass transfer cooling with a combustible gas, *ARS J.* **29,** 136–137 (Tech. Notes), Feb. 1959.

1967. Yuan, S. W., and Galowin, L. S., Transpiration cooling in the turbulent flow through a porous-wall pipe (in English), 9th Congrès Intern. Mecan. Appl., Univ. Bruxelles, 1957; **2,** 331–340.

1968. Pisarev, N. M., Determination of the diffusion velocity through the walls of a long cylinder with surfaces which are not co-axial (in Russian), *Trudi Ural'skogo Politekh. In-ta* no. 72, 233–236, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11290.

If the axes of the external and internal surfaces of cylinder are displaced in relation to each other over a distance b then the velocity of diffusion of gases through the walls of the cylinder is determinable by the formula

$$M = 2Dl(c_2 - c_1) \int_0^{\pi} \frac{d\varphi}{\ln(R/R_1)},$$

$$R = \sqrt{R_2^2 - b^2 \sin^2 \varphi} + b \cos \varphi$$

where R_1 and R_2 are the radii of the internal and external surfaces of the cylinder; c_1 and c_2 the concentration of gas inside and outside the cylinder, D the diffusion coefficient, l the length of the cylinder. With $b < R_1$, R_2 there is obtained

$$M = 2D\pi l(c_2 - c_1) \left[\left(\ln \frac{R_2}{R_1}\right)^2 - \left(\frac{b}{R_2}\right)^2\right]^{-1/2}$$

A. S. Monin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1969. Baylor, R. N., and Smith, F. C., The redistribution of hypersonic thermal loads due to structural cross-radiation, Proc. Fourth Midwest. Conf. Solid Mech., Austin, Texas, Sept. 1959; Austin, Tex., Univ. Press, 1959, 298–317.

A general method is presented for including the effects of internal thermal radiation on temperature distributions in structural enclosures heated by external convection. Analysis provides for the calculation of transient temperatures in two-dimensional thermally thin structures including the effects of internal radiant heat exchanges. M. J. Goglia, USA

1970. Callinan, J. P., and Berggren, W. P., Some radiator design criteria for space vehicles, *ASME Trans.* **81** C (*J. Heat Transfer*), 3, 237–244, Aug. 1959.

Authors analyze true radiators (no convection) as they may be used for rejection of waste heat from space vehicles. Three configurations are investigated: (1) smooth isothermal surface, (2) smooth surface with $T = f(x)$, (3) fin-and-tube with view factors less than unity and $T = f(x, y)$. The assumptions appear to be valid and not too restrictive for useful application of the results to practical cases. This work should be of quite valuable assistance in the planning and designing of space power plants in general, not merely for vehicles. Examples are included to show the procedure of designing for maximum heat rejection per unit weight. J. A. Scanlan, USA

1971. Siegel, R., and Usiskin, C., A photographic study of boiling in the absence of gravity, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-37, 8 pp.

A photographic study was made to determine the qualitative effect of zero gravity on the mechanism of boiling heat transfer. The experimental equipment included a container for boiling water and a high-speed motion picture camera. To eliminate the influence of gravity, these were mounted on a platform which was allowed to fall freely approximately 8 ft. During the free fall, photographs were taken of boiling from various surface configurations such as electrically heated horizontal and vertical ribbons. The heat flux was varied to produce conditions from moderate nucleate boiling to burnout. The results indicate that gravity plays a considerable role in the boiling process, especially in connection with the motion of vapor within the liquid.

From authors' summary

1972. Sagan', I. I., An experiment to measure the velocity of the circulation when sugar solutions of high concentration are boiling (in Russian), *Trudi Kievsk. Tekhnol. In-ta Pishch. Promsti* no. 17, 103–107, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11266.

1973. Martyushin, I. G., Some points in the hydromechanical calculations of apparatus with a boiling layer (in Russian), *Trudi Mosk. In-ta Khim. Mashinostr.* **13,** 145–158, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11310.

Attention is called to the fact that in the literature published on the subject so far very little has been said of the methods applicable and the types of calculations suitable for apparatus making use of a boiling layer. In addition, it is indicated that in the absence of hydromechanical calculations of apparatus designed for utilization of a boiling layer it is absolutely impossible to carry out the consequent thermal, technological and stability calculations. As a result of this state of affairs, author attempts to lay down the basis for a method of hydromechanical calculation to cover apparatus of the type mentioned. It is asserted that the determination of the dimensions of the section for the apparatus with a boiling layer leads to the determination of the numerical values of the point of pseudo liquefaction and "the number for pseudo liquefaction" (the relation of the working velocity in the free section of the apparatus to the critical velocity of the gas, when the layer of the powdery form of material goes over to the pseudo liquified state). It is shown that the transition of the granular material to the pseudo liquid state starts in conditions of equality of the mass forces (weight and Archimedean forces) with the force of the friction of the gas on the surface of the channels inside the layer. Calculation formulas are put forward. The insufficiency of their precision is, however, indicated and is explained by the incomplete knowledge of the structural factors of granular materials, to wit, the effective diameter of the particles in the layer, its porosity, the coefficients for the form of the channels and the part played by the free section. In conjunction with the above it is pointed out that the most reliable factor appears to be the experimental determination of the point of pseudo liquefaction. It is stated that the experimental determination of the point of pseudo liquefaction merges in practice with the measurement of the relation of the resistance of the layer of granular material to the velocity of the gas.

A schematic plan is given of the experimental apparatus used to follow up these objectives. The data obtained in the experiments are displayed in the form of functional dependencies of the fall of pressure in a column with a layer of granular material (weight – 500 g) on the velocity of the gas for four factors of quartz sand (with mean sieve dimensions for the particles of d = 0.297, 0.247, 0.180 and 0.158 mm). A method is developed for the graphical determination of the point of pseudo-liquefaction. A determination is made for the boiling layer on the assumption that it possesses a pseudo liquefaction regime such as would be met with in a "bubbling through" of a gas through the layer (analogous to diffusion). Note is made of the fact that the expansion of the boiling layer does not follow the principle of constancy in the fall of pressure and that at one and the same value of the number for pseudo liquefaction the actual expansion of the layer is significantly smaller than the calculated. The relationships are exhibited between the assigned porosity and the coefficient of "bubbling through" (the part by weight of the gas flow bubbling through the layer) and the pseudo-liquefaction number, introduced earlier by the author in his dissertation ["Investigation of the mechanism of the motion of gas and solid material in suspended bodies," Mosk. In-ta Khim. Mashinostr., Moscow 1952]. The similarity in method of calculation of the norm value in apparatus with a boiling layer and in the analogous method for mixers for liquids is pointed out. In concluding, emphasis is laid on the fact that experimental data at the present moment clearly show how impossible it would be to apply the investigated or any other method of calculation for apparatus with a boiling layer straight away without additional experiments. G. E. Khudyakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1974. Treschov, G. G., An experimental investigation of heat exchange mechanism at a boiling water surface (in Russian), *Teploenergetika* no. 5, 44–47, 1957.

Subcooled nucleate boiling in a flow channel of rectangular cross section was studied by high-speed photography at the All-Union Heat-Technical Institute. Empirical expressions for observed distribution of maximum bubble diameters, bubble growth-and-collapse curves, and thermal boundary-layer profiles are given. Using simple semi-theoretical considerations of heat transport per bubble, a relationship is obtained which agrees with the experimental data to ±10%, and which it is hoped will be useful for more general application. A. G. Fabula, USA

1975. Singh, K. P., and Havemann, H. A., Heat transport by liquids enclosed in vertical tubes, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956; 221–236.

Heat-transfer rates from a heated section to a cooled section of a vertical tube containing a liquid were measured. The cooling

occurred near the top of the tube, the heating near the bottom, the central portion of tube being essentially adiabatic. Thus, true natural convection currents were predominant only in heated and cooled sections at ends of tube. In middle portion turbulent mixing occurred with consequent vertical turbulent heat transport. Results are given for a liquid metal and for ordinary liquids. Increased heat transfer was obtained by allowing liquid to boil, except for large diameter tubes. Reviewer notes that Nusselt numbers (non-boiling) for water were on order of 100 times those for mercury. This indicates, as in the case of forced convection, the much greater ratio of turbulent to molecular heat transport for high Prandtl number fluids than for lower Prandtl number fluids.

R. G. Deissler, USA

1976. Singh, K. P., and Havemann, H. A., Transport of heat by convection and boiling in liquids enclosed in vertical tubes, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957; 277–292.

This is a continuation of work described in preceding review with a greater number of liquids and tube diameters and lengths. Data near the critical state are also obtained. It was found that there is considerable increase in heat transfer near the critical state.

R. G. Deissler, USA

1977. Vits, H., Graphical representation of absorption phenomena with special regard to the dehumidification of air by means of aqueous lithium chloride solution, Parts 1 and 2 (in German), *Forschung. Geb. Ing. Wes.* **24,** 5, 137–148; **24,** 6, 187–192, 1958.

The paper, in two parts, presents a new vapor pressure diagram for aqueous solutions of lithium chloride as used in air-conditioning and dehumidification processes. The diagram, based on recent U. S. measurements, indicates small deviations from the charts published in 1935 by Bichowsky.

Modified enthalpy-specific humidity ($i - x$) Mollier charts for moist air in the presence of lithium chloride solutions are also presented. Numerous examples of application of these charts are very fully discussed. The treatment of humidification and dehumidification processes with the aid of these charts is analogous to the usual application of the ordinary $i - x$ Mollier chart to air-conditioning problems. In most cases rapid graphical solutions are possible. The paper contains 14 references.

J. R. Moszynski, USA

Book—1978. Kuhl, H., Problems of crossflow heat exchangers [Probleme des Kreuzstrom-Warmeaustauschers], Berlin, Springer-Verlag, 1959, vii + 83 pp. DM 10.50. (Paperbound)

Effectiveness of multi-pan crossflow heat exchanger is calculated for different arrangements of passes. Author rediscovers an expression of effectiveness known at least in 1937 [Binnie, A. M., and E. G. C. Poole, *Proc. Camb. Phil. Soc.* **33,** p. 403] and calls it more suitable and more rapidly convergent than other known ones up to present. Results of calculations are expressed by a "factor of utility" (Ausnutzungsfaktor), which is the ratio of number of transfer units for the same effectiveness as compared to a counterflow heat exchanger. This is superfluous. Effect of molecular or eddy conductivity across the flow (author calls "mixing") is found to be small.

Paper, like many others of its sort, lacks clarity and scientific accuracy. The term "heat" is used without any definite meaning. "Local effectiveness" is defined as the ratio of heat flow from one stream to another to the heat introduced to the first stream, although there is certainly no heat introduced to any stream at any point except heat flow between the two streams.

L. S. Dzung, Switzerland

1979. Bunge, A. F., Experimental verification of theoretical calculations for finned-tube air-heaters (in Dutch), *Ingenieur* **71,** 26, w. 123–w. 140, June 1959.

Schmidt's calculations of fin efficiencies ["Die Wärmeleistung von begrippten Oberflächen," Karlsruhe 1950] had to be complemented by experimental data on the heat-transfer coefficients of the fin surface, which were available for free convection only. Author found that these are not applicable to forced convection, and therefore made extensive series of relevant measurements of heat transfer and pressure drop with one and more rows of finned tubes on a technical scale. The pressure drop due to the second row of tubes was found to be particularly low; it was not coupled with a similarly low heat-transfer coefficient. This influence of the presence of the first row on the effectiveness of the second row led to experiments with wire-gauzes inserted before the rows of tubes; again, some favorable results were obtained. The costs of different types of heaters are evaluated.

H. A. Vreedenberg, Holland

1980. Cyphers, J. A., Cess, R. D., and Somers, E. V., Heat transfer character of wire-and-tube heat exchangers, *ASHRAE J.* **1,** 5, 86–90, May 1959.

1981. Venkateswarlu, D., Some considerations in the selection and design of heat exchangers, *J. Sci. Engng. Res., India* **2,** 1, 44–50, Jan. 1958.

1982. Arpaci, V. S., and Clark, J. A., Dynamic response of heat exchangers having internal heat sources. Pt. III, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58–SA–39, 11 pp.

1983. North, B. F., Air-conditioning and pressurization of the Convair 880 turbojet transport, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59–AV–40, 18 pp.

1984. Vickers, P. T., Rotary regenerators for the Whirlfire vehicular turbines, ASME Gas Turb. Power Conf., Cincinnati, Ohio, Mar. 1959. Pap. 59–GTP–12, 10 pp.

1985. Ham, F. S., Shape-preserving solutions of the time-dependent diffusion equation, *Quart. Appl. Math.* **17,** 2, 137–145, July 1959.

Exact solutions of the diffusion equation are obtained which correspond to the diffusion-limited growth of ellipsoidal precipitate particles in a supersaturated solution. The solutions show that the growth of the precipitate surface is such that the ellipsoidal shape is maintained, even if the diffusivity is anisotropic. If a change in shape is observed as growth occurs it has to be attributed to some cause other than diffusion, therefore. While the solutions are not valid for the appearance of the original nuclei which grow into a new phase, owing to the importance of atomic fluctuations not accounted for by the diffusion equations, they do apply to the diffusion-limited growth at a later stage of the development of new phases.

Solutions are also given for hyperboloidal surfaces, though these have no obvious practical application. The solutions apply also to simpler geometries, such as rectangular, cylindrical, and spherical, which are special cases of the ellipsoidal coordinate systems.

R. L. Pigford, USA

1986. Dorweiler, V. P., and Fahien, R. W., Mass transfer at low flow rates in a packed column, *AIChE J.* **5,** 2, 139–144, June 1959.

The results of a theoretical and experimental study of mass transfer in packed columns at flow rate conditions in the laminar and transition regions are presented.

A tracer-injection technique was employed to determine the variation of concentration with radial position. The velocity dis-

tribution in the column was determined with a five-loop circular hot-wire anemometer. The test column was a four-inch vertical pipe packed with one-quarter inch spherical ceramic catalyst support pellets. Mass-transfer diffusivity and Peclet number were determined from two solutions of the differential-diffusion equation. Values of average diffusivity and Peclet number were calculated from the analytical solutions in terms of Bessel functions. A seminumerical solution in terms of homogeneous linear difference equations was used to calculate values of point diffusivity and Peclet number.

Data are presented showing the variation of diffusivity and Peclet number with radial position. The interaction of molecular and eddy mass-transfer mechanisms with decreasing mass velocity is illustrated. The average Peclet number is correlated with Reynolds number. Molecular, eddy, and total Peclet numbers are correlated with a modified Reynolds number. The eddy contribution considered at a point basis is found to vary at local flow conditions and can be defined on the basis of the flow conditions.

R. G. Nevins, USA

1987. Onda, K., Sada, E., and Murase, Y., Liquid-side mass transfer coefficients in packed towers, *AIChE J.* **5,** 2, 235–239, June 1959.

A study of the physical absorption of gas by water in a tower packed with raschig rings is presented. The experimental tower was 2.6 ft long with an inside diameter of 2.4 in., packed to a height of one foot. The absorption of pure carbon dioxide by water was studied. The liquid side mass-transfer coefficient is derived from the standpoint of two-film theory and from the standpoint of the penetration theory. A modified Nusselt number is presented which uses the apparent mean depth of liquid as a dimension of length. The authors report that this modified Nusselt number covers about 90% of the data reported, including the authors', within an accuracy of ±20%.

The penetration theory provides a simpler dimensionless formula which was applicable within an accuracy of ±20% to almost all data reported. Both theories show that the coefficient is dependent upon the Reynolds and Schmidt numbers. The data also show that the coefficient is a function of the total surface area of the packing.

R. G. Nevins, USA

1988. Barad, M. L., and Haugen, D. A., A preliminary evaluation of Sutton's hypothesis for diffusion from a continuous point source, *J. Meteorol.* **16,** 1, 12–20, Feb. 1959.

Sutton's hypothesis for diffusion from a continuous point source has been evaluated using the data obtained during Project Prairie Grass. It is found that the hypothesis predicts the observed concentration distributions only if there are two values of Sutton's "n," one to characterize lateral diffusion (n_y) and one to characterize vertical diffusion (n_z). Statistical tests indicate that n_y and n_z are invariant with distance between 100 and 800 m of the source, but that the values of n_y and n_z appropriate for these distances exceed the values within 100 m of the source. It is also shown that neither n_y nor n_z can be specified by n_w, the value of n found from a power-law fit to the wind profile in the lowest 8 meters.

From authors' summary

Combustion

(See also Revs. 1837, 1852, 1928, 2010, 2048, 2050)

1989. Vanpee, M., and Wolfhard, H. G., Comparison between hot gas ignition and limit flame temperatures, *ARS J.* **29,** 7, 517–519, July 1959.

Hot gas ignition temperatures of a variety of fuels have been determined and compared with limit flame temperatures of the same fuels. The ignition temperatures were taken under two conditions: A continuous jet of hot nitrogen flowing into a cold fuel-air mixture, and a continuous jet of hot air flowing into cold fuel. Limiting flame temperatures were determined by producing a diffusion flame in an atmosphere of air diluted with nitrogen. The nitrogen concentration required to extinguish the flame was noted and the limiting flame temperature calculated assuming stoichiometric combustion. It was found that, with the exception of a few combustibles, a correlation holds between hot gas ignition temperature and limit flame temperature. The effects of various additives, such as bromine, chlorine and methyl bromide, were also studied and corroborated this conclusion.

From authors' summary

1990. Levy, A., and Weinberg, F. J., Optical flame structure studies: Some conclusions concerning the propagation of flat flames, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 296–303.

Authors present a summary of conclusions based on studies of lean ethylene-air flames burning on Powling-Egerton-type flat flame burner operating at atmospheric pressure. Flow regime was studied with particle-track method. Particle tracks showed that reactant stream emerging within 3 mm of the burner periphery was diverted through a system of vortices before entering flame to burn at a level higher than central portion of flame, thus producing rim on flame. This phenomenon made the determination of burning velocity by the area measurement open to question. Particle-track-determined burning velocities were used in subsequent experimentation. Burning velocities were found to increase linearly with both composition and increased initial temperature. Authors conclude that effect of preheating is identical with effect of that addition of fuel which will produce the same increase in final flame temperature. Calculation of burning velocity from heat release profile data was found to agree best with experimental results when mathematical treatment of Spalding is used. Calculations of reaction rates assuming a Lewis number of 1.0 with diffusion taken into consideration fit the experimental data much better than calculations using a Lewis number of 0.0, assuming no diffusion.

T. P. Clark, USA

1991. O'Donovan, K. H., and Rallis, C. J., A modified analysis for the determination of the burning velocity of a gas mixture in a spherical constant volume combustion vessel, *Combustion and Flame* **3,** 2, 201–214, June 1959.

Authors repeat the analysis of Lewis & von Elbe [*J. Chem. Phys.* **2,** p. 283, 1934; "Combustion, flames and explosions of gases, Cambridge Press, 1938] for the measurement of speed of flame in gases in a constant volume bomb. Lewis and von Elbe's result was restricted to the early, essentially constant pressure, portion of the explosion by their assumption of linearity between the volume swept by the flame front and the fraction of the gas burnt. Authors attempt to remove this restriction by calculating the mean temperature of the gas from coordinated measurements of the location of the flame front and of pressure at various instants during the progress of combustion. If this were successful, they might then be able to calculate the flame speed at different pressures from the data of a single explosion, and their analysis results in the necessary equations to do this from the experimental data. The analysis is based on the assumption that other sources of error, such as heat loss to the walls or degradation by transport of heat within the gas, do not become significant in the later stages of the explosion. Even if these factors were not significant, their estimate of the mean temperature appears doubtful since it is an average over the radius, instead of being weighted volumetrically. No experimental work is reported.

M. A. Mayers, USA

1992. Cheng, S. I., and Kovitz, A. A., Theory of flame stabilization by a bluff body, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 681–691.

This paper comprises two new additions to the already exhaustive list [AMR **10**(1957), pp. 229–237] of bluff-body flame-stabilization models. In both new models it is postulated that a necessary condition for flame stabilization is the development of a local temperature maximum (marking the point of attachment of the downstream spreading flame front) in the shear region between the recirculation zone and the approaching unburnt gases. The distance from the downstream end of the flame holder to the point at which the temperature maximum first appears is assumed to be equal to the corresponding distance obtained from an empirical correlation of the authors' theoretical results for the ignition of a cold combustible stream by a parallel hot inert stream downstream from a flat plate with symmetric Blasius-type velocity profiles. In the first model this condition is coupled with the requirement that the heat transferred from the recirculation zone to the cool gases upstream from the temperature bulge be equal to the heat transferred from the burnt gases to the recirculation zone downstream from the temperature bulge. In the second model the original condition is instead coupled with the requirement that the distance to the point at which the temperature maximum develops be determined by the value of this maximum temperature and the heat transfer to a definite small stream tube at the outer edge of the recirculation zone. In both models, the coupling of the two criteria provides two equations for the distance to the temperature bulge, and these two equations are eventually combined to yield a relation for the blow-off velocity.

It is shown that good correlations of experiments on the dependence of blow-off velocity upon equivalence ratio and flame-holder diameter can be obtained with both models. On the other hand, the dependence of blow-off velocity upon pressure, which is correctly correlated by other existing theories, can not yet be predicted by either of these models. The new models are correct in accounting for the presence and importance of the recirculation zone, the appearance of a local temperature bulge, and the existence of the flame-spreading region. However, there is no place in these theories for turbulent transport upstream from the point of flame attachment as is often observed near blow-off, and it seems that the theories predict that near blow-off the point of flame attachment is usually much farther upstream than commonly observed.

F. A. Williams, USA

1993. Palmer, K. N., The quenching of flame by wire gauzes, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 497–503.

Factors influencing performance of wire-gauze flame arrestors are reported. Critical velocity of flame approach was found, above which the flame passed through arrestor. With single gauze layers this critical velocity was inversely proportional to gauze mesh width. Up to 5 layers of coarse mesh gauze were more effective than single ones, but any further increase in number of layers showed no improvement. Combinations of coarse and fine gauzes were less effective than fine gauze alone. Results are in general agreement with simple theory of quenching due to heat abstraction by gauze.

J. K. Kilham, England

1994. Rosen, G., On the classification of the chemistry in combustion experiments, *Jet Propulsion* **28,** 12, 839–841 (Tech. Notes), Dec. 1958.

Combustion theoreticians use two exponents, m and n, in representing overall chemical combustion reactions. This paper shows how these exponents can be related to classical combustion parameters. They can be determined by measuring the change in burning velocity with pressure at constant burned gas temperature and by measuring the change in burning velocity with burned gas temperature at constant pressure.

H. F. Calcote, USA

1995. Fristrom, R. M., Avery, W. H., and Grunfelder, C., Reactions of simple hydrocarbons in flame fronts—microstructure of C_2 hydrocarbon-oxygen flames, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 304–310.

Mass spectrograph was used to sample lean hydrocarbon-oxygen flames seated on flat-flame burner. Acetylene, ethylene and ethane were used as fuels. Quartz probes moved through flame front and relative concentrations of stable species were determined.

Results indicated that relative rate of disappearance of initial fuel and oxygen is the same for all three hydrocarbons. Rate of oxygen disappearance decreases when fuel is all consumed, although concentration of carbon monoxide is greatest at this position in flame. Concentration of other intermediates is small but all are a maximum concentration at position of maximum slope of hydrocarbon profile. Most important minor intermediate is formaldehyde. Luminous regions of flames of fuels differ and ethylene seems to be involved in production of luminosity. All hydrogen is oxidized by the time the initial hydrocarbon concentration reaches zero. Higher molecular weight hydrocarbons and all oxygen-containing compounds except formaldehyde are absent. No ozone or hydrogen peroxide was found.

T. P. Clark, USA

1996. Jeschar, R., and Hansen, M., Combustion with simultaneous heat transfer, Parts I and II, Mathematical derivation; Comparison of theory and experiments (in German), *Arch. Eisenhuttenw.* **30,** 6, 329–335, June 1959; **30,** 7, 397–405, July 1959.

Overall performance of gas-heated water-cooled industrial furnaces is considered under simplified conditions. Cylindrical geometry is assumed with axial gas flow and heat transfer only normal to the curved walls. The time and space rates of heat release by the gas flowing down the furnace are taken to be simple exponentials with constant coefficients. These parameters, with the rates of heat transfer to walls, flow rates and heating values, determine the resultant theoretical curves, which are calculated for various numerical values of interest, yielding a rough description of heat-transfer rates along the furnace axis. A calorimeter was constructed, consisting of a 30-mm steel tube coiled into a 865-mm ID cylinder coated with 20-mm thick schamotte. Each six coils were independently water cooled, over a total length of 5 meters. Gas and air were admitted axially, and also under premixed conditions, at rates varying from 1 to 50 free cubic meters per hour; temperatures and flow rates of water were measured. The resultant rates of 1 to 10×10^3 kcal/hour per set of six coils varied along the axis in qualitative agreement with the simplified theory.

R. A. Stern, USA

1997. Thring, M. W., A non-acoustic theory of oscillations in pressure-jet oil-fired combustion chambers, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 659–663.

Author presents a phenomenological theory of pressure oscillations observed in conventional residential heaters which burn oil in air. The idealized heater is assumed to consist of an air inlet pipe, an oil injection apparatus, a combustion chamber, and an exhaust stack. Oscillations in the oil injection rate are neglected. A number of different idealized oscillation mechanisms are investigated, all of which involve a coupling between two processes characterized by a combustion chamber residence time and a characteristic flow time in the inlet or exhaust pipes. Author considers cases in which (a) the air inlet supply rate is constant throughout the inlet pipe but is related to the pressure drop in the

inlet pipe by a first-order linear differential equation, (b) the pressure is constant throughout the inlet pipe but varies with time as a consequence of a difference between the mass flow rates into and out of the inlet pipe, and (c) the same model as (b) but applied to the exhaust stack instead of the inlet pipe. For each of these cases, author investigates the consequences of two possible phenomenological coupling equations: (1) variations in the inlet mass flow rate produce a proportional change in the temperature in the combustion chamber, and (2) variations in the inlet mass flow rate produce a proportional change in the time derivative of the temperature in the combustion chamber. For each coupling it is found that the constant of proportionality must be negative for oscillations to develop.

The criterion for the existence of oscillations is taken to be the vanishing of the coefficient of the first derivative in a resulting second-order linear differential equation for a pressure or mass flow rate. It is found that no oscillations can develop in cases (a, 2), (b, 1), (c, 1), and (c, 2). For case (b, 2) the frequency of the predicted oscillations is ten times larger than that of observed oscillations. It is concluded that the oscillation mechanism is (a, 1), which, in addition to predicting the observed frequency, agrees with experiment in indicating that oscillations may be reduced by increasing the pressure difference across the inlet pipe, decreasing the size of the inlet pipe, decreasing the resistance to the flow of exhaust gases through the stack, and decreasing the total mass flow rate through the exhaust stack. Unfortunately the article contains many misprints, as do a number of other articles in the same volume. F. A. Williams, USA

1998. Sobolev, N. N., Frosh, S. E., Kulikova, N. M., Lotkova, E. N., Malyshev, G. M., Rodin, G. M., and Shukhtin, A. M., Pyrometric study of the flame of an oxygen-silicon-aluminum fuel, *Soviet Phys.-Tech. Phys.* **4,** 4, 451–456, Oct. 1959. (Translation of *Zh. Tekh. Fiz.* **29,** 4, 506–514, Apr. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

A powdered silicon aluminum fuel was burnt in oxygen at atmospheric pressure in a special chamber. The diagram of the chamber does not show the burner, but it is said to be an oil burner. The chamber was water cooled and the flame could be viewed through quartz windows in the sides. The mean value of the brightness temperature was found by means of an optical pyrometer to be 2280K, while the color temperature was 3125K. The flame has an absorptivity close to unity, but nevertheless the absorptivity varies sufficiently with wavelength to give a color temperature considerably higher than the brightness temperature. This is explained by the presence of a cold layer in the flame which does not change the color temperature but reduces the brightness temperature. Thus, the temperature of the hot layer will be close to the color temperature observed. The high emissivity of the hot region is due to the presence of tiny particles of liquid alumina. M. W. Thring, England

1999. Sobolev, N. N., Belousov, M. M., Rodin, G. M., Sviridov, A. G., Skorobogatov, N. G., and Faizullov, F. S., Flame temperature of a liquid-fuel jet engine, Part 1, *Soviet Phys.-Tech. Phys.* **4,** 1, 24–31, July 1959. (Translation of *Zh. Tekh. Fiz.*, **29,** 1, 27–37, Jan. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

It is shown that in the visible region the emission spectrum of the flame of a liquid-fuel jet engine (LFE) working on mixtures such as "tonka"* + HNO_3 and kerosene + HNO_3 is continuous, and the energy distribution in the spectrum can be described by Wien's formula. The absorptive power of the flame increases from the red to the violet part of the spectrum, and falls off as the oxidant excess coefficient $\bar{\alpha}$ increases. Flame temperatures have been measured both by color and brightness methods under different working conditions of the LFE. It is shown that for values of $\bar{\alpha}$ close to the stoichiometric value, the measured temperature agrees with the calculated value obtained on the assumption of steady-state flow. The gas temperature in the combustion chamber has also been measured. From authors' summary

2000. Sobolev, N. N., Kitaeva, V. F., Rodin, G. M., Faizullov, F. S., and Fedorov, A. I., Flame temperature of a liquid-fuel jet engine. Part 2, *Soviet Phys.-Tech. Phys.* **4,** 1, 32–37, July 1959. (Translation of *Zh. Tekh. Fiz.*, **29,** 1, 37–45, Jan. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The emission spectrum of the flame of a liquid-fuel jet engine (LFE) has been investigated in the visible region of the spectrum when the engine was working on a mixture of kerosene and liquid oxygen. It is shown that the emission spectrum is continuous and the absorptive power is nearly unity. The color temperature has been measured under different working conditions. It is shown that in the case of stoichiometric composition experimental and theoretical values of the temperature are nearly equal. From authors' summary

2001. Gerstein, M., Correlation and prediction of flame properties with special reference to liquid hydrazine, *ARS J.* **29,** 7, 514–516, July 1959.

A large background of experimental data, analytical studies and correlations exist for hydrocarbon air flames. Much less work has been done with propellants of interest in the rocket field. It is possible, however, that some of the experimental and analytical techniques developed for flames of fuels burning in air will be useful when applied to the fuels and oxidants used in rockets. This paper presents a summary of some of the predictions and correlations which have been reported. A brief discussion of the application of some of these correlations to the liquid hydrazine decomposition flame is also included. Such a flame, using a propellant with relatively simple flame kinetics and which can support a flame when introduced either as a liquid or a gas, may well serve to bridge the gap between gas phase combustion studies and combustion of condensed phases, such as liquid and solid monopropellants. From author's summary

2002. Gordon, J. S., Estimation of performance of fuels with hydrogen peroxide oxidizer, *ARS J.* **29,** 7, 530–532 (Tech. Notes), July 1959.

2003. Nagamatsu, H. T., and Martin, E. D., Combustion investigation in the hypersonic shock-tunnel driver section, *J. Appl. Phys.* **30,** 7, 1018–1021, July 1959.

An investigation was made of the combustion of stoichiometric mixtures of hydrogen and oxygen with a varying percentage of helium in the constant-volume driver section for a hypersonic shock tunnel. The pressure was measured as a function of time for a number of initial pressures, mixture ratios, and multiple sparks for ignition. The maximum pressures observed were close to that expected for smooth burning. When detonation was encountered, the ratio of the peak pressure to the initial pressure was about 50. From authors' summary

2004. Mikhailov, A. I., Investigation of the flow in the combustion chambers of gas-turbine engines (in Russian), *Trudi Labor. Dvigatelei, Akad. Nauk SSSR* no. 3, 43–62, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11033.

The author, by analyzing the results of an aerodynamic investigation of the flow (on models) of gas in the combustion chambers of gas-turbine engines equipped with vortex forming blades, comes to the conclusion that it would be possible to prepare a schematic plan of the actual flow in the chamber by adopting the following concept. The flow of air entering the chamber through the impeller is examined as a twisted annular jet, which from one side is bounded by the heat pipe, and from the other mixes with the gases

of the zone of return currents, which always form in the central part of the chamber. The process of turbulent exchange between the jet and the zone of return currents has much in common with free turbulent mixing, the principles of which are studied. Basing his conception on this fact and disregarding the twisting of the flow, author evolves a method for the approximate calculation of the fields of the axial component of the flow's velocity in the transverse sections of the combustion chamber with assigned parameters for the impeller, for the chamber's profile and the principle of distribution of the secondary air entering the chamber through the orifices in its wall. The proposed method of calculation is only suitable for cases of the working of the chamber with so-called cold blow-through. Since comparison of the experimental data obtained with cold scavenging and with combustion confirms the analogous character of the fields of velocity in both cases, author recommends this method of calculation for the qualitative evaluation of the flow's structure in the chamber during combustion. A comparison is made between the results obtained by the author's method and the experimentally ascertained fields of velocity.

O. V. Yakovlevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2005. Malkin, S. A., Aerodynamic calculations for gas generators (in Russian), *Gaz. Prom-st'* no. 12, 8–15, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12433.

A method is put forward for a calculation-determination of the hydraulic resistance and stability of a fuel layer in gas generators when taking into account the separation of the layer into zones (clinker, burnt out and fresh fuel) differing from each other by structure and thermal conditions. For the determination of the hydraulic resistance of the layer the aid is sought of the generalized criterial relation

$$\lambda_a = F(R_a) \quad \text{or} \quad \frac{2\Delta P}{\rho v^2}\frac{d_a}{H} = F\left(\frac{\rho v d_a}{\mu}\right) \quad \text{where}$$

ΔP is the resistance of the layer with height H_M in mm, water column; v is the velocity of the gas flow carried off to the full section of the layer in m/sec; ρ, μ are, respectively, the density in kg/sec^2/m^4 and the coefficient of the dynamic viscosity of the medium in kg/sec/m^2. The value d_a entering into the formula is the assigned diameter of a particle linked with the mean diameter of the particle by the relationship $d_a = \Psi d_m$, where Ψ is the hydraulic equivalent, determinable graphically in the form of a function of the relatively free volume (porosity) of the layer in relation to the type of fuel. In order to compute the influence of the multiplicity of layers of the fuel charge on the aerodynamics of the gas-generating process tests were carried out on two-layer charges with differing dispersions of the particles. The corresponding dependence $\Delta P = f(v)$ is put forward together with the determination of the critical velocity of the flow, leading to the disruption of the stability of the fuel layer. The resistance of the fire-bar grating was measured by blowing through with air of a model of the gas generator with a diameter of 450 mm. The results of all the tests were successfully presented in the form of a well-defined relation

$$\zeta = f(R)$$

or

$$\frac{2\Delta P}{\rho W^2}\left(\frac{d_r}{D_r}\right)^{0.4} = f\,\frac{pWd_r}{\mu}$$

where ΔP is the resistance of the fire-bar grating with the adjoining layer of clinker in mm, water col.; W is the velocity of the flow in the interspace passages between the particles of the clinker; D_r is the hydraulic diameter of the air slits in the fire-bar grating; d_r is the hydraulic diameter of the interstitial channels. The procedural method is stated for the aerodynamical computation of the gas-generating process, based on the calculations of the hydraulic resistance and stability of the separate zones. The author indicates that the probable precision of this computation would be within a ±7% limit.

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2006. Levy, A., and Weinberg, F. J., Optical flame structure studies: examination of reaction rate laws in lean ethylene-air flames, *Combustion and Flame* **3,** 2, 229–253, June 1959.

Several flat ethylene-air flames have been studied by the "inclined slit" method under conditions of varying initial temperature and composition. Temperature profiles so deduced together with burning velocities determined by a particle track technique have been used to derive distributions of heat release rate and other relevant parameters. These results are evaluated for their kinetic significance. It is concluded, inter alia, that profiles of effective orders and activation energies indicate a varying reaction scheme such that an overall reaction model, while entirely untenable at lower temperatures, may be of use for the zones near the maximum heat release rate. These zones appear to characterize the behavior of the flame as a whole and their rate laws approach those determining blow-out under highly mixed conditions. Temperature disequilibrium effects are shown to be unimportant for the flames considered.

From authors' summary

Prime Movers and Propulsion Devices

(See also Revs. 1930, 1970, 1992, 2004, 2038, 2040, 2109)

Book—2007. Armstrong, L. V., and Hartman, J. B., The diesel engine; its theory, basic design, and economics, New York, The Macmillan Co., 1959, xviii + 360 pp. $8.75.

The authors have succeeded in presenting a compact volume covering theory, basic design and application of the diesel engine. As such, it permits rather brief treatment of the more complex phases of each subject, and therefore is judiciously sprinkled with references to authoritative works. The inclusion of elementary definitions indicate that the text is geared to the advanced student, and not for the professional engineer. However, its clear style should make it a worthwhile engineering reference and class textbook. Problems are given in the appendix for the various chapters. The authors have drawn on their long experience in the internal-combustion field and stressed the practical aspects of design, fuel combustion, and field application, much of which has not appeared in print to date. Particularly noteworthy is the definition of all symbols and abbreviations, inserted prior to the general text.

W. M. Kauffmann, USA

2008. Emin, O. N., The critical and boundary regimes of the work of a stage of a gas-turbine (in Russian), *Trudi Mosk. Aviats. In-ta* no. 82, 30–48, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12468.

The results of a computational investigation are furnished regarding the possible regimes for the elementary stage of a gas turbine, in particular, the critical regimes when in one or other section of the gaseous tract a velocity is reached equal to the velocity of sound, or the boundary regimes when with the expansion of the gas in the oblique section of the cascade the axial component of velocity attains the velocity of sound. The critical and boundary regimes are examined of the cascade of the nozzle apparatus and the working disk in the turbine's system. Results are also given of the investigation regarding the influence of the basic geometrical parameters of the turbine on the production of

critical and boundary regimes of work. The investigation was made without taking into account the changes in the parameters of the flow with reference to the height of the blade (that is for the elementary stage) and without consideration of the losses in the circulating part of the turbine. Consequently the relations and dependencies obtained can only be looked upon as being of a qualitative character and cannot be used directly for the investigation of the working regimes of the real turbine.

B. S. Dorogov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2009. Fortini, A., Hendrix, C. D., and Huff, V. N., Experimental altitude performance of JP-4 fuel and liquid-oxygen rocket engine with an area ratio of 48, NASA Memo 5-14-59E, 27 pp., May 1959.

The performance of a rocket engine having a nozzle area ratio of 48 was experimentally measured at four altitudes and corrected to vacuum conditions. A comparison of experimental performance with that of a sea-level engine having an area ratio of 5.5 was made. The propellant combination JP-4 fuel and liquid oxygen was used for both engines. The chamber pressure was constant at 600 lb/sq in. abs. Altitudes were obtained by an ejector system utilizing the rocket exhaust gas as the pumping fluid. Results indicate the large-area-ratio engine gives a specific impulse of 311 lb-sec/lb at vacuum conditions. At sea level, the large-area-ratio engine encountered flow separation within the nozzle and the specific impulse was 223 lb-sec/lb. The results also include measured heat-transfer rates and heat loads of the engine.

From authors' summary

2010. Goldaev, I. P., The optimal parameters in the process of combustion in liquid-fuel rocket motors (in Russian), *Trudī Khar'kovsk. Aviats. In-ta* no. 17, 261-274, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12477.

A thermodynamic calculation was made for the combustion of different fuels (kerosene, benzene, ethyl alcohol, hydrazine, aniline, liquid hydrogen) in combination with liquid oxygen and nitric acid. The results obtained enabled several deductions to be made. Each pressure in the combustion chamber corresponds to an optimal coefficient of excess oxidizing agent α, at which the maximum temperature is reached; in proportion with the increase of pressure the optimal value of α tends to attain unitary value, which is explained by the suppression of dissociation at high pressure. The specific thrust of the motor has its maximum value too with the determined value of coefficient α; however, the optimal value of α in relation to the specific thrust is considerably less than the optimal value of α in relation to the temperature; this is explained by the relation of the molecular weight of the products of combustion and the adiabatic indicator to the coefficient of excess oxidizing agent. The higher the heat production of the fuel the smaller becomes the value of the coefficient of surplus oxidizing agent. In this work with widely known fuels and oxidizing agents the most favorable pressure in the combustion chamber was found to be in the range of 20-50 kg/cm^2.

A. B. Eerokhi

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2011. Oswatitsch, K., Thrust with addition of heat at supersonic velocity (in German), Dtsch. Versuchsanstalt Luftfahrt, Ber. 90, 29 pp., Mar. 1959.

In conventional supersonic ramjet, relative entrance velocity is reduced to subsonic before adding heat. Article considers possibility of obtaining thrust by heating at supersonic velocity and utilizing pressure increase from condensation shock. Author treats only theoretical aerodynamic aspects, not practical ones such as heat supply and efficiency of combustion (atomic source may become available). No experimental data are given, but analysis (linearized equations inadequate) indicates that for supersonic flow about long, slender body such as two wedges with maximum sections back-to-back, only favorable place for heating is at trailing edge (hence term "stern" heating). Very high supersonic velocities are required for good efficiency. Thrust is impossible for constant-area-duct ramjet having infinitesimally thin wall if approach velocity is supersonic, though theoretically possible for subsonic velocity. Article has little direct practical application, but is of general background interest and, subject to possible reservations because of assumptions, should help to guide further work along these lines.

C. W. Smith, USA

2012. Daum, N., The Griffon aircraft and the future of the turbo-ram-jet combination in the propulsion of supersonic aeroplanes, *J. Roy. Aero. Soc.* **63,** 582, 327-339, June 1959.

The Twelfth Louis Blériot Lecture describes turbo-ramjet engine and its performance in the Nord Aviation Griffon II. Principles of turbojet and ramjet engines are presented with discussion of how their characteristics can be advantageously combined. Impressive performance figures of Griffon airplane are given with short discussion of future applications of combined engine.

W. F. Davis, USA

2013. Kappus, P. G., Recoverable boost vehicles with air-breathing power plants, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-16, 8 pp.

Because the first stage of a space project is a much larger and costlier piece of equipment than the remaining components, it offers the greatest opportunity for potential savings. For this reason a very high interest has developed in recoverable, reusable first-stage vehicles, which will make possible significant savings in many areas—development, procurement, and operation. For this reason it seems advisable to investigate the great possibilities inherent in recoverable boost vehicles with air-breathing power plants as discussed in this paper.

From author's summary

2014. Rohlik, H. E., and Crouse, J. E., Analytical investigation of the effect of turbopump design on gross-weight characteristics of a hydrogen-propelled nuclear rocket, NASA Memo 5-12-59E, 37 pp., June 1959.

Axial-flow, mixed-flow, and centrifugal pumps driven by single and twin turbines were considered. Pump operates between 50 psia at inlet and 1200 psia at outlet; its speed was chosen high but just below cavitation limit. Turbine design parameters are: tip speed = 1400 fps, hub radius/tip radius = 0.79 at exit, inlet temperature = 1860°R, inlet pressure = 1000 psia. Variables investigated include bleed rate (ratio of turbine flow to pump flow), pump efficiency, turbine efficiency, number of turbine stages, and structural parameter (ratio of structural weight to propellant weight). A reference payload of 10,000 lbs was assumed. Rocket mission was assumed to be a vertical flight in a uniform gravitational field with a burnout velocity of 26,000 fps at an altitude of 530 miles.

Authors found that the lowest rocket gross weights were obtained with an axial-flow or mixed-flow pump driven by a single turbine of at least 8 stages. One point in pump efficiency is worth 0.2% in gross weight with a structural parameter of 0.1, or 0.6% with a structural parameter of 0.2. Turbine and pump efficiencies are more important than their weights. One point in pump efficiency is equivalent to approximately 13% in pump weight; and one point in turbine efficiency is equivalent to about 7% in turbine weight.

Reviewer feels that although the assumed rocket mission is somewhat restrictive, the method of analysis used by authors can be extended to other missions.

T. C. Tsu, USA

2015. Edwards, R. N., and Kuskevics, G., Cesium-ion rocket research studies, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-32, 8 pp.

A cesium-ion rocket is described which features a perfusing ion emitter and employs the accelerate-decelerate principle in a cylindrical geometry. Power loss and system weight analysis yields an optimum design point. An experimental research program in the development of the ion rocket accelerator and evaluation of its barrier problems is outlined. Supporting research includes studies of ion generation, ion extraction, electrical breakdown, and ion interception. From authors' summary

2016. Forrester, A. T., Problems associated with the testing of ion thrust chambers, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-35, 4 pp.

Primary requirements of an ion-motor test facility are a vacuum system capable of handling high material efflux at very low pressures and electrical equipment capable of supplying high voltages and currents. Ion-current measurements must be divorced from confusing effects of secondary photoelectric and high field emission processes. Measurements must be made of neutral efflux in the exhaust and component erosion rates. The effectiveness of devices and methods for insuring electrical neutrality of the exhaust should be tested. Direct measurement of the thrust produced by such a device is also desirable for correlation with voltage and current measurements. From author's summary

2017. Bottorff, J. A., and Ellis, H. B., Propulsion requirements for space-station erection, ASME Aviation Conf., Los Angeles, Calif., Mar. 1959. Pap. 59-AV-17, 7 pp.

The rapid advances in rocket and space technology will lead eventually to the establishment of a manned space station. The first true, manned space station probably will be assembled in an orbit around the earth. The personnel for construction of the space station, as well as the materials of construction, will have to be transported to the desired location in space by a rocket vehicle, probably launched from the earth. During the construction phase of the space-station erection, there will be a need for auxiliary-propulsion power units for transferring both personnel and material from the launching vehicle to the construction site. For the purposes of this paper, only propulsion systems which are applicable to the actual construction phase of the space station are considered. The propulsion requirements for reaching the desired position in space where the station is to be erected is beyond the scope of this paper. Some of the more important requirements which must be met by a propulsion system which is to be utilized in the erection of a space station are: (a) Safety and reliability; (b) versatility; (c) high performance.

From authors' summary

Magneto-fluid-dynamics

(See also Rev. 2045)

2018. Kerrebrock, J. L., Diffusion in neutral and ionized gases with extreme pressure gradients, Heat Transf. and Fluid Mech. Inst., Univ. Calif., Los Angeles, Calif., June 1959, 193-206.

This analytical study considers flows in which diffusion resulting from a pressure gradient is a dominant factor because the pressure gradient and the resulting diffusion is normal to the flow direction. The system considered is that of a vortex flow in which strong radial pressure gradients are produced by large tangential velocities. The study is restricted to two-dimensional vortical flows. Two examples of diffusion are considered: (1) Two electrically neutral, diffusing gases, where there is no diffusion due to body forces and in which diffusion due to pressure gradient and concentration are of equal importance. Equations are formulated for binary diffusion in two-dimensional vortex flow for the case of gases of nearly equal molecular weights, (2) The diffusion of electrons of an ionized gas, in which case the concentration diffusion is negligible and pressure diffusion and diffusion due to electromagnetic body forces are of principal importance. Solutions are obtained only for small currents and magnetic fields.

R. M. Drake, Jr., USA

2019. Green, H. S., Ionic theory of plasmas and magnetohydrodynamics, *Physics of Fluids* **2,** 4, 341-349, July-Aug. 1959.

Equations of change, fluxes as functions of gradients and forces, and polarization and magnetization as functions of correlations between positions and velocities of neighboring particles are derived for case in which the relativistic and quantum effects are negligible and the changes in macroscopic variables are small over distances of the order of the correlation length. A development of the statistical mechanics of plasmas in equilibrium, required for the calculation of the polarization of a plasma in equilibrium, is included as an appendix.

The derivation of the equations of change is facilitated by separating exactly effects of long-range and short-range forces; the aforementioned application of statistical mechanics is facilitated by avoiding the technical difficulties encountered in evaluating the partition function for a plasma.

As a significant part of the paper, author attempts to clarify certain confusions found in the literature of plasmas, particularly confusions regarding the induced charge and current densities and the generalization of Ohm's law. Although good backgrounds in electrodynamics and in thermodynamics (classical, statistical, and irreversible) are required for a complete understanding of this paper, reviewer believes that any investigator of plasmas would find something of interest in this paper.

E. L. Knuth, USA

2020. Carini, G., Magneto-fluid-dynamics of viscous compressible flow (in Italian), *Atti Accad. Naz. Lincei, R. C. Cl. Sci. Fis. Mat. Nat.* (8) **25,** 6, 470-473, Dec. 1958.

Author's purpose is to derive the equation of energy in magnetohydrodynamics of viscous compressible fluids. The starting point is the equations of hydrodynamics in the Navier-Stokes formulation modified by the addition of terms originated from the electromagnetic phenomena, Maxwell equations of magneto-electrodynamics and Ohm's law. Author mentions that the formulation of the problem with the use of Minkowski equations will be the subject of a forthcoming paper. The equation of motion is multiplied by an infinitesimal volume and integrated with respect to time t. Each term of the so-obtained equation is discussed very thoroughly, giving the following expressions: elementary work of the mass forces, of the shearing forces, the energy originated from the Poynting vector, etc. The final form of the energy equation is left in the differential form.

M. Z. v. Krzywoblocki, USA

2021. Ludford, G. S. S., and Murray, J. D., On the flow of a conducting fluid past a magnetized sphere, AFOSR TN 59-424 (Inst. Fluid Dynam. Appl. Math., Univ. Maryland TN BN-169; ASTIA AD 214 774), 20 pp., Apr. 1959.

An analytical study of the steady flow of an incompressible, inviscid, finite conducting fluid past a magnetized sphere. The first-order effects of the magnetic field and conductivity are examined and paraboloidal wakes of vorticity and magnetic intensity are formed, the former being half the size of the latter. The vorticity, generated by the nonconservative electromagnetic force is logarithmically infinite on the sphere. The case of a dipole at the center of the sphere is studied and a drag coefficient is given. The flow is completely independent of the conductivity of the sphere, provided it is finite. The sphere of infinite conductivity is discussed. R. A. Gross, USA

2022. Reagan, D., Some compression waves in plasmas, *Physics of Fluids* **2,** 1, p. 93 (Letters to the Editor), Jan.-Feb. 1959.

2023. Pesler, E. L., Jr., and Sears, W. R., The prospects for magneto-aerodynamics—correction and addition, *J. Aero/Space Sci.* **26,** 5, p. 318 (Readers' Forum), May 1959.
See AMR **12** (1959), Rev. 1032.

Aeroelasticity

(See also Rev. 1695)

2024. Guiraud, J. P., Unsteady aerodynamic forces on deformed low aspect ratio wing (in French), *ONERA Publ.* 95, 37 pp., Feb. 1959.

A slender wing solution based upon the equation

$$\varphi_{yy} + \varphi_{zz} = \frac{1}{c^2}\varphi_{tt},$$

where φ denotes velocity potential, y spanwise coordinate, z coordinate normal to the wing plane, t time, and c speed of sound, is presented. The solutions have physical reality if

$$\mathrm{AR}\sqrt{|M^2-1|} \ll 1 \text{ and either } k \gg 1 \text{ or } \mathrm{AR}\, k\, M \ll |M^2-1|.$$

AR is aspect ratio, M Mach number, and k reduced frequency based upon semi-root chord. The present investigation surpasses former work of Merbt and Landahl [AMR **6,** (1953), Rev. 3175] in that it allows the direct evaluation of the aerodynamic coefficients which enter into the Galerkin equations for flutter calculations. These are of the form

$$\iint p_i(x,y)\, h_j(x,y)\, dx\, dy$$

where h_j denotes the $j^{-\text{th}}$ mode, while p_i is the pressure due to the $i^{-\text{th}}$ mode and the integration is to be performed over the wing area. The modes can be arbitrarily chosen. This means that the procedure of calculation involves a number of integrations. Auxiliary tables are included in the report.

A. I. van de Vooren, Holland

2025. Coupry, G., and Piazzoli, G., Study of flutter in transonic flow (in French), *Rech. Aéro.* no. 63, 19–28, Mar.-Apr. 1958.

The aim was to investigate the effects of airfoil thickness and shock-wave movement on the unsteady aerodynamic coefficients for a thick symmetric profile at zero mean incidence. In Part 1, the theoretical problem is tackled, the nonlinear potential flow equations being replaced by linear equations with variable coefficients. To solve the problem, it was supposed that the corresponding steady flow solution was known. In addition, the flows in the regions ahead and behind the shock were both taken to be uniform, and these two regions were treated separately. The form and position of the shock wave was determined by using Hugoniot's relation, when the free stream was subsonic.

In Part 2, the method is applied to calculate (1) the unsteady aerodynamic coefficients for a low supersonic Mach number, (2) the shock movement (with increasing subsonic Mach number) on an airfoil at a steady incidence, and (3) the phase lag between shock movement and flap movement for various frequencies of flap vibration. Very good agreement was obtained with experiment in cases (1) and (2), and less good agreement in (3). It is shown that the value of the coefficients at low supersonic speeds can be related to those obtained by the classical linearized theory at a different ('fictitious') supersonic Mach number. From these results it appears that flutter with one degree of freedom is confined to a much smaller range of supersonic Mach numbers than that predicted by the linearized theory.

A. W. Babister, Scotland

2026. Kharlamov, A. A., Modelling of aerodynamic reactions on a vibrating wing in a plane flow of air (in Russian), Intercollegiate School Conference on the Application of Modelling in Electroengineering Problems and on the Mathematics of Modelling, Moscow, 1957, 179 pp.; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 10978.

Paper contains basic information from the theory of aerodynamical reactions on a vibrating wing: the stationary and non-stationary theories. A description is given of an electronic and of an electromechanical model of the vibrations of a wing in a plane flow, which reproduce the aerodynamical reactions in the aforementioned theorems. Results are furnished of the experimental investigation of the phenomena of flutter on the models, of the relation of the critical speed and frequency to the change of parameters. Results are compared for the stationary and the nonstationary theories.

From author's summary

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2027. Blyumina, L. Kh., and Zakharov, Yu. G., Vibrations of cylindrical bodies in an air flow (in Russian), Investigations on the dynamics of construction; Moscow, Gos. Izd-vo po Str-vu i Arkhitekt., 1957, 44–60; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 10987.

Making use of a wind tunnel ($D = 3m$), an investigation was carried out on the nature of the vibrations of cylindrical bodies in a flow of air directed perpendicularly to the generatrix of the cylinder. The tests were performed with different systems of flow, corresponding to the speed of the oncoming stream from 20 to 60 m/sec, with the cylinder elastically fastened. The magnitude of the pressure on the cylinder was recorded by means of low inertia membranous gages, connected with the gutter openings; the pulsations of velocity in the flow were measured with a thermoanemometer; the vibrations of the cylinder were recorded by strain gages fixed on the cylinder; in addition, a mechanical record of the cylinder's vibrations was also kept. The result was that, in all cases of cylinder vibration, the vibration takes place at natural frequency (depending on the elasticity of the fastening) in a plane transversely placed in relation to the oncoming flow. This deduction is confirmed by the observations of TsNIPS on vibrations of S. P. Strelkov [*Zh. Tekhn. Fiz.* **9,** no. 19, 1939] on the autovibrational nature of the said phenomenon.

An inconsistency is noted of the explanation given for the appearance of vibrations in a cylinder in a flow of air as due to periodic tearing away from the cylinder of Benara-Karman vortices. The case is examined of wind resonance, that is when the frequency of the tear-away vortices of Benara-Karman coincide with the natural frequency of the vibration of the cylinder. Oscillogram records of the cylinder's vibrations are given, for different velocities of the flow, for the magnitude of resistance of the cylinder in relation to the R number, and oscillograms of velocity pulsations beyond the cylinder. Together with the strain-gage readings records are produced of the vortex break aways at extreme positions of the cylinder. The frequency of the break-away is the same as the frequency of the cylinder's vibration. On the basis of the data obtained the relation is given of the coefficient of transverse force C_z to the dependence on the R number. The maximum value for C_z corresponds to a regime of wind resonance and is equal to 0,12. The results obtained in this study might find their application in calculations for constructions of the tower type.

V. M. Shalov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2028. Bobbitt, P. J., Tables for the rapid estimation of downwash and sidewash behind wings performing various motions at supersonic speeds, NASA Memo 2-20-59L, 177 pp., May 1959.

Equations for the downwash and sidewash due to supersonic yawed and unswept horseshoe vortices have been utilized in formulating tables and charts to permit a rapid estimation of the flow re-

locities behind wings performing various steady motions. Tabulations are presented of the downwash and sidewash in the wing vertical plane of symmetry due to a unit-strength yawed horseshoe vortex located at 20 equally spaced spanwise positions along lifting lines of various sweeps. (The bound portion of the yawed vortex is coincident with the lifting line.) Charts are presented for the purpose of estimating the spanwise variations of the flow-field velocities and give longitudinal variations of the downwash and sidewash at a number of vertical and spanwise locations due to a unit-strength unswept horseshoe vortex. Use of the tables and charts to calculate wing downwash or sidewash requires a knowledge of the wing spanwise distribution of circulation.

Sample computations for the rolling sidewash and angle-of-attack downwash behind a typical swept wing are presented to demonstrate the use of the tables and charts.

From author's summary

Aeronautics

(See also Revs. 1584, 1589, 1861, 1875, 1983, 2012)

2029. Loh, W. H. T., Minor circle flight for boost glide vehicles, *ARS J.* **29,** 4, 300–301 (Tech. Notes), Apr. 1959.

Approximate range equation of a hypersonic glider flying along a great circle path has been derived recently by Eggers and Allen [NACA TN 4046, Oct. 1957; AMR **12** (1959), Rev. 1581]. Under assumptions similar to those of these authors, the present paper derives the maximum range equation for a glider flying along a minor circle path. When a certain angle $\lambda_0 = \pi/2$, the minor circle becomes a great circle, and the maximum range equation reduces to that obtained by Eggers and Allen.

E. Leimanis, Canada

2030. Nicolo, G. B., On the vertical take-off aircraft—determination of optimum performance (in Italian), *Aerotecnica* **38,** 3, 155–170, June 1958.

Astronautics

(See also Revs. 1589, 1970, 2013, 2014, 2017)

2031. Weber, R. J., and Pauson, W. M., Achieving satellite rendezvous, *ARS J.* **29,** 8, 592–595 (Tech. Notes), Aug. 1959.

To gain on a target moving on the same circular orbit, it is proposed to deflect the the thrust vector from an initially horizontal position in such a manner as to compensate for the increasing centrifugal force by the radial component of the thrust. This constitutes a very simple guidance problem since the thrust angle required is twice the angular distance traveled. Thus after 45° traveled, during which the vehicle accelerates, the thrust is radial, and after 45 more degrees (deceleration period), the thrust is again tangential but is opposite to the initial direction. The total gain during this maneuver depends on the thrust-to-weight ratio. If more gain is required, than the vehicle has to coast awhile with the radial thrust before switching over to the deceleration phase.

Authors show that such a constant radius technique takes an excessively long time if the thrust ratio is low, and is most inefficient if the thrust ratio is high. This result is not surprising since the radial component of the thrust does not produce work but goes into waste.

Reviewer believes that the problem itself can be hardly justified. Since the interceptor has to arrive at the target orbit via another orbit, he will not establish himself on the target orbit if he does not meet the target, but will save his fuel to attempt a rendezvous from another point of his approach orbit. Thus the case of being on the same orbit but separated is most unlikely.

G. S. Gedeon, USA

2032. Breakwell, J. V., The optimization of trajectories, *J. Soc. Indust. Appl. Math.* **7,** 2, 215–247, June 1959.

Author presents a general theorem related to the Morse statement of the problem of Bolza in the calculus of variations applicable to the formulation of several important missile trajectory optimization problems. He discusses problems in obtaining maximum range under varying angle of attack, varying thrust direction and throttle without and with effects of drag during re-entry and glide period, effects of earth rotation, problems of boost to maximum velocity, climb in minimum time, and interception in minimum time, and finally some numerical results. Since formulations result in systems in ordinary differential equations with initial values given for some variables and terminal values for the rest, usually Lagrange multipliers, the theorem presents the Lagrange multipliers as derivatives of the maximum payoff function with respect to initial values of the functions to be varied. This should aid in estimation of unknown initial values needed for forward integration in the iterative numerical solution of the problems.

M. L. Juncosa, USA

2033. Copeland, J., Interplanetary trajectories under low thrust radial acceleration, *ARS J.* **29,** 4, 267–271, Apr. 1959.

Interplanetary trajectories resulting from constant radial acceleration (toward or away from the sun) are obtained in terms of tabulated functions. For sustained acceleration greater than a critical value, the vehicle spirals to escape. For accelerations less than critical, the vehicle moves in precessing orbits with perihelion or aphelion on the initial orbit using outward or inward thrust, respectively. Some examples of trajectories are given and their implications discussed.

From author's summary by E. Leimanis, Canada

2034. Benezra, J. N., A short form method for determining near-circular orbit quantities, *ARS J.* **29,** 3, 216–218 (Tech. Notes), Mar. 1959.

Application of standard perturbation technique to basic equations permits expressing orbit quantities and their sensitivity to injection errors as explicit functions of injection errors and altitude. Calculations can be made quickly and with sufficient accuracy for preliminary performance work.

Comparison of presented approximate results with more rigorous ones determined in cited references would have been interesting.

S. Ostrach, USA

2035. Adler, A. A., Calculation of re-entry velocity profile, *Jet Propulsion* **28,** 12, 827–828 (Tech. Notes), Dec. 1958.

2036. Cashmore, D. J., Minimum gravitational losses for rocket motion near a planetary surface, *J. Brit. Interplanetary Soc.* **17,** 2, 52–57, Mar.–Apr. 1959.

Assuming absence of atmospheric drag and transverse thrust forces, author derives equations for computing incremental velocity gains for vehicles under thrust operating in a gravitational field. It is recognized that the effect of a gravity field is minimized if the acceleration is infinite (impulsive thrust), but neglecting this trivial case author assumes minimum gravitational loss is incurred for trajectory hugging a planetary surface.

Using the simple trajectory equation for the assumed minimal loss path, expressions for incremental velocity are obtained for conditions of constant acceleration and constant thrust. For the former, solution in terms of elliptic integrals is found. For the latter, an approximate solution using a series of incomplete gamma functions is presented.

Parametric graphs (various accelerations for the two cases) are presented, permitting determination of minimum velocity deficits incurred because of operation in the gravitational field.

W. W. Berning, USA

2037. Bergqvist, B., The optimization problem for rocket vehicles subjected to medium and high accelerations: a literature survey (in English), *Astronautik, Sweden* **1**, 3, 101–117, 1959.

2038. Giorgieri, L., Optimum burning time of high altitude rockets (in Italian), *Aerotecnica* **38**, 4, 195–209, Aug. 1958.

2039. Okhotsimskii, D. E., and Eneev, T. M., Some variational problems with a bearing on the lauching of an artificial satellite to the earth (in Russian), *Uspekhi Fiz. Nauk* **63**, 1A, 5–32, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12068.

The question is investigated regarding the evolution of an artificial satellite for an assigned orbit; the method is worked out for solving the various problems arising. In paragraph 1 an investigation is made of the simultaneous selection of a schedule for directing the impulse motion and for fuel consumption characteristics. This problem is solved on the assumption that aerodynamic forces are absent, while the field of impulse is taken to be plane-parallel. It is shown that the optimal schedule for the change in the angle of tangential impulse appears to be the linear with time: $\tan \varphi = \tan \varphi_0 - C_2 t$. It is also shown that by selecting the optimum time, the velocity increase and also altitude increase should be carried out by the application of a momentary impulse at the very beginning of the motion. Deductions regarding the horizontal direction are made with consideration for the action of the force of gravity. If the assigned time differs from the optimum then the change of direction to the horizontal should be made by the application of a supplementary impulse, imparted to the end of the stage. In paragraph 2 the problem is examined of the selection of the optimal schedule for a multistage accelerator, on the assumption that the consumption of fuel is known. Relations are deduced enabling complete solutions to be effected for the maximum motion of the composite rocket. The relations deduced contain two arbitrary constants, linked up with the system of direction; in this category may be considered the values of the angle of tangential impulse at the end of trajectory φ_k and at the beginning of trajectory φ_0. Accepting these constants, the position may be attained that, with the time fixed for the motion on a part of the flight, the given height y_k and the equality to zero of the vertical component of velocity are guaranteed at the end of this run. Also, having accepted these constants it is possible to determine the end magnitude of velocity u_k and distance x_k. Curves are given for two-, three- and four-stage accelerators. Analyzing these curves the conclusion is reached that, with a given number of stages in the rocket and with a given end-relation for the μ_k determined, limitations appear in regard to the possibilities of effecting different combinations of height and velocity of motion. Paragraph 3 contains a generalization of the problem on the guiding of the sputnik into orbit in the case of its motion in the central field of gravity with consideration for the Earth's revolution. The functional of the problem is found. In the case being examined the relation of the functional to the schedule of change of the angle of tangential impulse $\varphi(t)$ cannot be put forward in its simplest form. However, the paper gives a full system of equations, together with the boundary conditions, which furnish a solution for the problem under consideration. It is shown that with the use of a number of simplifying assumptions the problem merges with that of the optimum direction into orbit, which was solved for the case of the plane-parallel field for the force of gravity.

N. I. Zolotukina

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2040. Rodean, H. C., Rocket thrust termination transients, *ARS J.* **29**, 6, 406–409, June 1959.

Thrust transients occuring at shut-off of rocket engines can alter design values of final rocket velocity and direction. Author treats transients analytically, on basis of idealized conditions, and presents results (impulse increment resulting from exhaust of gas in combustion chamber) in generalized graphical form. Data for fixed and variable nozzle geometry and zero and finite ambient pressures are provided.

The assumptions underlying the analysis are clearly stated, and restrict the applicability of the results because of the difficulty of knowing that they are satisfied. Author suggests that assumptions are satisfied under certain conditions of liquid and solid propellant shut-off.

J. S. Arnold, USA

2041. Yegorov, W. A., Some problems of dynamics of flight to the Moon (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk, Matem. In-ta, Akad. Nauk SSSR, Moscow, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 72.

2042. Gontkovskaya, V. T., Application of modern calculation methods to the analytical methods of celestial space mechanics (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk, GI. Astron. Observ. Akad. Nauk SSSR, Leningrad, 1957; *Ref. Zh. Mekh.* no. 1, 1958, Rev. 73.

2043. Zigel', F. Yu., Questions on the connection between the delimited problem of three bodies and the motion of artificial satellites of the earth (in Russian), *Byul. Vses. Astron.-Geod. O-va* **21**, 14–16, 1958; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12066.

Concepts are advanced relating to the utilization of collinear and triangular points of Lagrange's libration in the system Earth-Moon as interplanetary stations in cosmic flights. As the collinear points of libration are points of unstable equilibrium it is proposed to maintain "the artificial stability" of the stations by means of jet motors. It is also proposed to make use of the periodic solutions of the delimited problem of three bodies for obtaining the closed (periodic) orbits of the Sputniks—circular, elliptical and loopshaped—with the necessary disposition relative to the Earth and the Moon; curves are furnished for the above orbits to cover the case of identical mass-bodies of finite magnitude.

P. P. Lavrinenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2044. Schindler, G. M., On satellite librations, *ARS J.* **29**, 5, 368–370 (Tech. Notes), May 1959.

Author considers satellite made of two spherical equal masses joined by rigid weightless rod of length $2e$ with center of mass at radius ρ from earth's center. Rotation oscillation about axis through center of mass parallel to orbit axis is analyzed. For circular orbit, oscillation period follows from a hyperelliptic integral which author discusses and solves for amplitudes tending to zero and $\pi/2$; former gives a previous finite result, latter infinity.

Reviewer notes omission of terms in rate of orbit angular velocity and moment of inertia of spheres about own axes in basic equation [5b]; [5b] implies erroneously that oscillation occurs with single sphere (e equals zero); engineering solution of [5b] is obtained by ignoring terms of order e^2/ρ^5 when simple pendulum equation results. Author's retention of such terms is not justified since satellite path perturbations are of same order and have been (rightly) ignored.

J. M. Evans, Australia

2045. Kraus, L., and Watson, K. M., Plasma motions induced by satellites in the ionosphere, *Physics of Fluids* **1**, 6, 480–488, Nov./Dec. 1958.

Linearized hydrodynamic equations were solved simultaneously with Poisson's equation to obtain the drag of charged body moving at high velocity through a plasma. Changes in ion and electron densities in the wake were also determined. Solutions were obtained for two extreme cases of high-density plasma at thermody-

namic equilibrium and of low density nonequilibrium. Results for each limiting case were similar. Formulas derived in this exploratory paper are of limited practical use due to restrictive nature of the assumptions. A. E. Fuhs, USA

Ballistics, Explosions

(See also Revs. 1729, 1733, 1739, 1838, 1852, 1991, 1993, 2036, 2040)

2046. Adler, L. B., and Luker, J. A., Detonation overpressures in saturated knallgas–steam mixtures, *Combustion and Flame* **3,** 2, 157-167, June 1959.

Reflected pressures corresponding to the development of detonation in saturated mixtures of knallgas and steam at 100 C were measured. The maximum pressure observed was about three times that predicted for theoretical reflected detonation by solution of the Chapman-Jouguet detonation equations and equations for normal shock reflection. Composition limits defining nonreactive and detonatable regions for the particular experimental system employed were also determined. Some considerations applicable to the study of detonation in gaseous mixtures having long detonation stabilization distances are noted, and pressure time records of different stages of the transition from flame to detonation are shown. From authors' summary

2047. Kogarko, S. M., Investigation of detonation wave pressure by the method of crusher rod compression, *Soviet Phys.-Tech. Phys.* **4,** 1, 113–122, July 1959. (Translation of *Zh. Tekh. Fiz.* **29,** 1, 128–141, Jan. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

The existence in the detonation wave of a reaction zone with a pressure higher than the one of the products of reaction at the Jouguet point has been proved by measuring detonations of limiting hydrogen-air mixtures and methane-air mixtures in a large-diameter (305-mm) tube.

The measured numerical values of reflected wave pressures in limiting methane-air mixtures are in good agreement with those calculated by means of the modern detonation theory, which states that the pressure in the shock wave is about twice as great as that in the reaction products at the Jouguet point.

The measured pressure of a traveling wave in limiting methane-air and benzene-air mixture detonations is equal to about twice the pressure of reaction products at the Jouguet point.

From author's summary

2048. Serel', C. S., Investigation of the detonation of weak mixtures (in Russian), *Trudi Mosk. Aviats. In-ta* no. 92, 31–48, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11076.

A brief account is furnished of the advantages of using weak mixtures of fuel-air for combustion in internal-combustion engines with spark ignition. Possible causes for the phenomenon of detonation in internal-combustion engines are investigated on the basis of data given in the literature. The procedure followed and the results obtained in the experimental examination of the changes in the detonating liability of combustion mixtures as they become impoverished are described. The experiments were carried out in a single-cylinder motor, fitted with a carburetor, variable compression at 900 revs/min, and temperature (suction stroke) of 100°. Changes in the detonation efficiency of the fuel in relation to the composition of the mixture were evaluated with the help of a comparison of the magnitude of the optimum (in accordance with the motor's power) angle of advancing the ignition with the limit of detonation for the advance. At the same time details of the mixtures used were recorded. The intensity of the detonation was determined by means of indicator diagrams. In the experiments use was made of non-detonating fuels (commercial isooctane with an addition of an ethyl liquid) and, as a detonating fuel, benzine B-70. To avoid all possibility of the fuel in the cylinder separating out in layers and in order to be able to verify the starting of detonations of poor and of fully combustible mixtures a system was introduced of a preliminary and full vaporization of the fuel and of mixing these vapor with the air. In addition, observations were made on the tendency of homogeneous mixtures to ignition from the compression in relation to their composition. For this purpose the motor was revved by means of an electric motor; indicator diagrams were also made. The experiments established that the maximum intensity for detonation and ignition from compression took place with mixtures of stoichiometrical composition. With increased impoverishment of the mixture the intensity of the detonation decreases, but the power developed also falls with the appearance of detonation. The experiments also showed that ignition from compression precedes a pre-flame chemical reaction, making the transition to thermal explosion easier. The appearance of two-stage ignition near the limits of ignition is sharply marked.

Yu. F. Dityakin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2049. Karlikov, V. P., The linearized problem of the propagation of a powerful explosion in a heterogeneous atmosphere (in Russian), Avtoref. Diss. Kand. Fiz.-Matem. Nauk, MGU, Moscow, 1958; *Ref. Zh. Mekh.* no. 7, 1958, Rev. 7436.

2050. Laffitte, P., and Bouchet, R., Suppression of explosion waves in gaseous mixtures by means of fine powders, Seventh Symposium (International) on Combustion, London and Oxford, Aug. 28–Sept. 3, 1958; New York, Academic Press, 1959, 504–508.

Authors report on efficiency of fine powders for extinction of flames propagating at high velocities. In first series of experiments, quenching material was distributed by shock disturbances preceding the deflagration wave. Method was effective only for flame fronts with velocity less than 450 m/sec at time of quenching. If powder was distributed independently prior to passage of explosion wave, quenching was achieved for all detonation waves irrespective of their velocity. For a given detonation wave, minimum quantity of powder necessary was inversely proportional to surface area of particles. Relative effectiveness of various sodium and potassium salts was also investigated.

J. K. Kilham, England

2051. Bennett, F. D., Cylindrical shock waves from exploded wires of hydrogen-charged palladium, *Physics of Fluids* **2,** 4, 470-471 (Research Notes), July–Aug. 1959.

2052. Berger, S. A., and Holt, M., Spherical explosions in sea water, Proc. Sixth Midwest. Conf. Fluid Mech., Austin, Texas, Sept. 1959; Austin, Texas, Univ. Press, 118–139.

Object of this investigation is the early growth of a spherical explosion in sea water resulting from the detonation of an uncased spherical charge of PETN. The field of disturbance is found by integrating the equations of unsteady motion of an inviscid compressible fluid with spherical symmetry (Eulerian form). Authors use the numerical method of characteristics as an extension of a calculation in air carried out by Berry, Butler and Holt [*Proc. Roy. Soc.* (*A*) **227,** p. 258, 1955]. Paper contains details of mathematical methods used in the different regions (detonation, isentropic, nonisentropic, compressed sea water) of the field of disturbance. Results (tables and figures) show characteristic differences between the behavior of a charge exploding in air and in sea water; e.g. in the latter case the expansion region behind the detonation zone is much more confined, while the nonisentropic region and the compressed water region are more extensive.

C. Franze, Germany

2053. Togunov, Yu. V., Some principles involved in breaking-up rock with explosives (in Russian), *Sb. Naucbn. Tr. Magnitogorskii Gomo-Metallurg. In-ta* no. 12, 119–132, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 7015.

An examination is made of the laboratory tests on the breaking up of marble slabs 0.3 to 0.5 m^3 in volume by explosions of elongated charges weighing 0.8, 1.4, 2.3, 3.6g along the line of least resistance measuring 30 to 130 mm. The dimensions of the marble pieces were determined by sieve analysis. On the basis of these experiments certain principles were established; for instance, the relation between the mean dimensions of the pieces (and the limit of expenditure of explosive) and the line of least resistance, and a number of others, in particular the proportionality of the surface of the pieces to the specific expenditure of explosive.

G. I. Pokrovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2054. Zaid, M., and Paul, B., Oblique perforation of a thin plate by a truncated conical projectile, *J. Franklin Inst.* **268,** 1, 24–45, July 1959.

Authors' previous analyses of normal perforation of thin plate by high-speed projectiles are generalized to include truncated cones, at oblique striking angles. A complete velocity-displacement history is obtained for the most general case. Results are presented in graphical form. From authors' summary

2055. Kramer, S. B., Velocity of tank fragments, *ARS J.* **29,** 5, 363–364 (Tech. Notes), May 1959.

An investigation was carried out to determine the positions as functions of time of the sections of an exploded tank in the upper atmosphere idealized as a 6-ft diam sphere, since the geometry involved afforded a desirable distribution of the fragments and permitted immediate derivation of descriptive equations. The sphere was pressurized using helium, and was considered to have primacord over its surface so that upon detonation a spherical scattering of fragments would occur. To simplify calculations it was supposed that 10 such fragments of equal mass and size were generated in a given detonation.

From author's summary

Acoustics

(See also Revs. 1776, 2065)

2056. Kaspar'iants, A. A., The problem of sound wave propagation in "Van Der Waals Gases and Liquids," *Soviet Phys.-Acoustics* **4,** 4, 336–343, May 1959. (Translation of *Akust. Zh.* **4,** 4, 325–332, Oct.–Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Sound velocity and absorption are derived by linearization of Van der Waals equation, for the gaseous, liquid, and critical regions. Agreement with other work is cited.

P. Rudnick, USA

2057. Sutton, P. M., Propagation of sound in plate-shaped solid delay lines, *J. Acoust. Soc. Amer.* **31,** 1, 34–43, Jan. 1959.

This paper examines the theory of sound propagation in a solid delay line, using a simple treatment of diffraction instead of a full-scale treatment in terms of the wave equation and boundary conditions. The theory used is based on cylindrical waves and the elementary theory of diffraction by a slit. Results are obtained showing the delay time, shape of the pulse, etc., depending on the frequency in the range 5 to 30 Megacycles. A comparison with experimental results indicates general agreement with the theory. Author's work is compared with that of Holden [*Bell. System Tech. J.* **30,** p. 965, 1951; AMR **5** (1952), Rev. 1309] and Mapleton [*J. Appl. Phys.* **23,** p. 1346, 1952; AMR **6** (1953), Rev. 2176] who treated the problem in terms of the wave equation.

J. M. Jackson, Scotland

2058. Adkhamov, A., Theory of the propagation of ultrasonic sound in liquids (in Russian), *Uch. Zap. Tadzh. In-ta* **10,** 114–124, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12226.

Formulas are derived for the velocity C and for the coefficient of absorption of ultrasonic sound in liquids, these being based on hydrodynamic equations obtained from the classical model of substance as being systems of material points with a central principle of interaction. Assuming that the radial function of distribution ($q(r)$) depends weakly on the temperature T and the specific volume v and by disregarding the relations of the integrals determining the internal pressure and the internal energy, with T and v the following is obtained

$$c^2 = \frac{5kT}{3m} - \frac{3\pi}{3mv}\int_0^\infty r^3\Phi^1(r)\,g(r)\,dr$$

where m is the mass of the molecule, k Boltzmann's constant, r the distance between the molecules, $\Phi(r)$ the potential energy of interaction between two molecules, expressed as a function r. By making use of the numerical results for the model of the liquid consisting of "solid" spherical molecules, the interaction between which is calculated by the formula containing two hyperbolic terms, author computes the relation of the velocity of sound with the specific volume and the temperature. The velocity of sound decreases with the increase of v and increases (v remaining constant) with the increase in temperature. By inserting the numerical values for the constants for $\Phi(r)$ in the equation, author calculated the magnitude of C in argon along the line of equilibrium of the liquid-vapor near the critical point, representing qualitatively correctly the temperature dependence of C.

B. B. Kudryavtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2059. Krom, M. N., and Chernov, L. A., The effect of fluctuations in the incident wave on the mean intensity distribution in the vicinity of the focus of the lens, *Soviet Phys.-Acoustics* **4,** 4, 352–358, May 1959. (Translation of *Akust. Zh.* **4,** 4, 341–347, Oct.–Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Earlier solutions of variations in the diffraction image caused by random fluctuations of amplitude and phase in a focused plane wave (acoustic or light) have been limited by mathematical difficulties to very small or very large fluctuations in the incident wave. This paper develops an expression for the mean intensity near the focus in the form of a rapidly converging infinite series for all intermediate cases under the assumption that lens dimensions be large in comparison with the correlation radius of the fluctuations. Even for unfavorable cases, eight terms of the series provide an accuracy of 5 decimal places. Graphs are presented showing calculated mean intensity at the focal plane and along the principal axis of the lens for a number of mean square values of combined amplitude and phase fluctuation.

W. W. Soroka, USA

2060. Tartakovskii, B. D., On the diffraction of sound waves in converging beams, *Soviet Phys.-Acoustics* **4,** 4, 366–371, May 1959. (Translation of *Akust. Zh.* **4,** 4, 355–360, Oct.–Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Theoretical study of the focusing of sound waves in the case of relatively small ratios of system dimensions to wavelength. Taken into account are nonuniform distribution of amplitude over the wave front, wave aberration and large aperture angle. Green's theorem, subject to Kirchhoff's approximation of neglecting dif-

fraction on the boundary, is used to describe the acoustic field. Debye's method for optical systems is adapted to evaluating the acoustic field near the focus. The sound pressure maximum is found not at the focus but somewhat nearer the focusing system.

W. W. Soroka, USA

2061. Lyamshev, L. M., The scattering of sound by elastic cylinders, *Soviet Phys.-Acoustics* **5,** 1, 56–61, Aug. 1959. (Translation of *Akust. Zh.* **5,** 1, 58–64, Jan./Mar. 1959 by Amer. Inst. Phys., Inc., New York, N. Y.)

A formal solution is given for the scattering of a plane sound wave by an elastic cylinder of circular cross section. The scattered field is found to differ essentially from that for a rigid cylinder wherever the axial component of the phase velocity of the incident wave coincides with the phase velocity of one of the traveling-wave modes of the cylinder. Experimental measurements of reflection coefficient versus angle of incidence are presented for brass, aluminum and steel cylinders and exhibit qualitative agreement with the theoretical predictions.

J. W. Miles, USA

2062. Tyutekin, V. V., Scattering of plane waves by a cylindrical cavity in an isotropic elastic medium, *Soviet Phys.-Acoustics* **5,** 1, 105–109, Aug. 1959. (Translation of *Akust. Zh.* **5,** 1, 106–111, Jan./Mar. 1959, by Amer. Inst. Phys., Inc., New York, N. Y.)

Author investigates the problem of the scattering of a plane longitudinal wave by an infinite cylindrical cavity in an isotropic elastic medium. Author restricts discussion to the case of normal incidence of the wave on the cavity. Expressions are derived for coefficients in scalar and vector potentials corresponding to the n-th cylindrical wave. The case $n = 0$ is considered in detail, and curves are given showing the dependence of zeroth-order coefficient on the elastic parameters. It is shown that, as in the case of a spherical cavity, resonance of the cavity occurs; in this case, however, resonance occurs only for small values of the shear modulus. Author also considers case where cavity is filled with air and shows that if the radius of cavity is small compared to the wavelength in air, then the air does not contribute any significant effect.

T. K. Caughey, USA

2063. Zverev, V. A., and Kalachev, A. I., Measurement of the interaction of sound waves in liquids, *Soviet Phys.-Acoustics* **4,** 4, 331–335, May 1959. (Translation of *Akust. Zh.* **4,** 4, 321–324, Oct.-Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

From phase modulation of a 1-MC wave elicited by a 3-KC wave, the derivative of sound velocity with respect to pressure is measured at one atmosphere for water, salt solution and alcohol. Results agree with static measurements.

P. Rudnick, USA

2064. Ribner, H. S., New theory of jet-noise generation, directionality, and spectra, *J. Acoust. Soc. Amer.* **31,** 2, 245–246 (Letters to the Editor), Feb. 1959.

The elements of a complete theory of jet noise are set forth from the well-known notion that flow noise arises from pulsations of turbulent eddies.

F. E. Borgnis, Germany

2065. Chernov, L. A., The acoustics of a moving medium, *Soviet Phys.-Acoustics* **4,** 4, 311–318, May 1959. (Translation of *Akust. Zh.* **4,** 4, 299–306, Oct.–Dec. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

This is a review of literature covering effects of wind and turbulence on atmospheric sound transmission, and emission of sound from moving sources.

P. Rudnick, USA

Micromeritics

(See also Rev. 1739)

Book—2066. Jarocki, W., Sediment movement in currents [Ruch rumowiska w ciekach], Gdynia, Poland, Wydawnictwo Morskie, 1957, 356 pp.

A very comprehensive treatise on sediment problems, the study and determination of the quantity of material transported by water, includes these most significant topics: water action and its results, laws of sediment movement, deformation of river channels; sampling and determination of sediments, laboratory analysis; solid runoff computation, empirical methods. The second part of the book is dedicated to the sediment and bed load in the rivers of Poland. Contents of the book are of particular value as a combination of methods and experience in Western Europe and Russia.

This book could have great success if translated into English and enriched with American experience. Bibliographical index contains 8 Polish, 33 Russian, 22 German, 10 French and 23 English titles; this fact shows its universality. Our readers would find here many interesting and little-known facts. The field of sedimentation is very important, and has few treatises of this kind.

S. Kolupaila, USA

2067. Eguiasaroff, I., A solution to the problem of sediment discharge which takes into consideration the effect of the high concentration bed layer (in French), *Houille Blanche* **14,** 3, 308–317, May/June 1959.

An extension of the formula proposed by the author at the 1957 A.I.R.H. Congress to the case of nonquadratic flow around the grain: this formula involves a linear relationship between the mean concentration module $p''/\sqrt[3]{i}$ (where p'' is the weight concentration of solids weighed in water, and i is the energy gradient) and the relative excess of tractive power $(N - N_0)/N$ (N = tractive power and N_0 = tractive power when sediment begins to be picked up). An account is given of experiments which check the formula referred to.

From author's summary

2068. Lamble, J., An approximate method for sediment-removing structure design calculations (in French), *Houille Blanche* **13,** B, 744–758, Dec. 1958.

Author revises the theory of suspended load in permanent uniform regime according the theory of Schmidt-Rouse. He discusses and develops an approximate theory of the behavior of a suspension in nonuniform regime, which occurs in structures such as settling basins, sand and silt traps. By making certain simplifying assumptions author derives a general solution which appears as a superposition of a uniform regime—steady concentration distribution in the direction of the flow—and a perfect settling regime in which no material is lifted again in suspension.

Observations at two sand traps in France are presented to demonstrate the applicability of the theory, and curves are given enabling a rapid computation of the dimensions in the hydraulic design of sediment-trapping structures.

G. A. Heyndrickx, Belgium

2069. Weiss, M. A., and Worsham, C. H., Atomization in high velocity airstreams, *ARS J.* **29,** 4, 252–259, Apr. 1959.

An experimental study was made of the drop sizes obtained on injecting a liquid into large hot airstreams of sustained high velocity. The liquid, a molten synthetic wax, was injected contrastream or costream through simple cylindrical tubes. Downstream, a traversing probe withdrew a representative sample of the stream, cooled it and froze the droplets. The collected solid particles were analyzed by sedimentation and by sieving. The results were

correlated empirically by the dimensionless equation

$$\frac{X\rho_A V^2}{\sigma_L} = 0.61 \left(\frac{V\mu_L}{\sigma_L}\right)^{2/3} \left(1 + \frac{10^3\rho_A}{\rho_L}\right) \left(\frac{W\rho_L\sigma_L\mu_A}{\mu_L^4}\right)^{1/12}$$

Mass median diameter (X), air density (ρ_A), relative velocity (V), liquid viscosity (μ_L) and mass injection rate (W) were changed over 4- to 25-fold ranges. Surface tension (σ_L), liquid density (ρ_L) and air viscosity (μ_A) were not changed significantly.

From authors' summary

2070. Mitchell, R. L., and Pilcher, J. M., Improved cascade impactor for measuring aerosol particle size in air pollutants, commercial aerosols and cigarette smoke, *Indust. Engng. Chem.* **51,** 9, 1039–1042, Sept. 1959.

Theory of impaction treated in previous researches [Davies and Aylward, 1951; Ranz and Wong, 1952; and Einbinder, 1955] is reviewed; on this basis the Battelle Cascade Impactor described in Pilcher, Mitchell and Thomas (1955) was improved, using optimal jet-to-slide clearance and wall-to-slide distance. Systematic tests were carried out on the jet-to-slide clearance which influences the sharpness of cutoff, and on the slide-to-wall distance which causes impaction on the wall, termed "aerodynamic wall loss." Final design based on these findings is described, having six jets and a volume flow rate of 12.5 liters per min. Calibration was carried out by (1) mass analysis, (2) microscopic counting of uniformly sized particles, and (3) microscopic measurement of non-uniformly sized particles. These techniques are described. Wall-loss studies on the final design were made by radiochemical methods which yield more accurate and reliable readings than do light-measuring methods. K. J. DeJuhasz, USA

2071. Lyshevskii, A. S., Some characteristics of the widening of the jet of sprayed liquid in a medium offering counterpressure (in Russian), *Nauchn. Trudi Novocherkasskii Politekhn. In-ta* **39,** 53, 71–79, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12577.

The semi-empirical relation is given of the angle of conicity of the jet of sprayed liquid, ejected from the sprayer, to the geometrical form of the outlet orifice (a cylindrical orifice, a conically tapering orifice, a conically expanding orifice and others) and to the Reynolds number. This relation is based on one side on the theory of the free jet; on the other, on Gol'fel'der's experiments [DVS. Sb. Monogr. po in. Lit., ONTI NKTP SSSR, 1936].

I. A. Shepelev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2072. Yamagata, K., Nishikawa, K., and Kawano, M., On the flow of pulverized coal in the exhauster, *Bull. JSME* **2,** 5, 17–22, Feb. 1959.

In the exhauster that feeds the boiler furnace with fuel in the mill, the blades of the exhauster wear out violently due to the pulverized coal-air mixture treated in it. As a countermeasure against this wear phenomenon, it is more effective to adopt lacerated blades instead of common straight blades than to change the material of blades. This report aims to provide a basis for wear-proof measure by grasping the motion of the pulverized-coal in the exhauster. As the result of the experiment, the following conclusions were drawn:

(1) In case of straight blades, most of the powder flows along the blade surface.

(2) In case of the lacerated blades, the powder flows from the tips of lacerated teeth drawing a parabolic line, but hardly touches the blade surface. From authors' summary

2073. Kneschke, A., Concerning the fineness and evenness of a ground material (in German), *ZVDI* **101,** 11, 413–418, Apr. 1959.

Based on the surface distribution of a ground material's grain structure the grades of "fineness' and "evenness" are established by the average and the pattern of distribution. Both values are arrived at analytically through the residual function. The formulas evolved for this interrelation apply to every material lending itself to grinding and can be numerically evaluated, particularly for a Rosin-Rammler material.

From author's summary

Porous Media

(See also Rev. 2086)

2074. Notarov, V. D., and Betin, D. I., The method of determination of the coefficient of filtration of separate water-bearing levels (contours) by the sum total of the pumping yield from the wells, under working conditions prevailing in the Krivorozhsk basin (in Russian), *Byul. Nauchno-tekh. Inform. N.-i. Gornorud. In-ta* no. 3, 58–66, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11336.

A method is propounded for the determination of the coefficient of filtration of separate water-bearing contours when passing through the shaft of their wells without the segregation of one level from another. Authors base their argument on the assumption that water-bearing layers in their natural state are completely isolated from each other by powerful water-impermeable interlayers and that the only hydraulic link between them is the sinking of wells. The output of the wells is assumed to be equal to the algebraical sum of the output of the separate water-bearing levels. In the calculations the authors make use of the Dupuis equations. When deriving the calculation equations the following concepts form the guiding principles: The first equation is derived from the condition that in the passage through the well after cutting across each water-bearing level by drilling, there is a halt (in the drilling) and measurements are carried out at a steady water level. Two other equations are derived from the results of two sets of pumping at different outputs from this level. Having found the hydraulic characteristics of the given level, the drilling is started and again stopped when the next level is cut across. The measurement of the level and two sets of pumping enable three equations to be derived and determines the hydraulic characteristics of this level. An example is furnished for the calculations of the coefficients of filtration of three water-bearing levels.

V. A. Vasil'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2075. Nikolaevskii, V. N., On exact and approximate solutions of a plane problem of infiltration for mixed boundary conditions (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 102–105, Oct. 1957.

Paper deals with the two-dimensional flow through a vertical reservoir intersected by a horizontal diaphragm transpierced by an axial slot. For determining the supplementary resistance caused by the slot presence, an exact method based on conformal transformations and using the Christoffel-Schwartz formula is applied, as well as an approximate method which admits a constant vertical derivative of the flow potential along the slot (equal to the ratio of the flow discharge to the slot width).

A comparison of the theoretical results with experimental data for a reservoir with equal length and width shows that the differences are negligible, being smaller than those resulting from calculation errors. R.-J. L. Bally, Roumania

2076. Zheltov, Yu. P., On the formation of vertical cracks in a layer by means of liquid infiltration (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 56–62, Aug. 1957.

Paper concerns the formation of cracks by high-pressure injection of a liquid into a well. Injection aims at obtaining a considerable increase of the well discharge. As distinguished from other previous papers, author takes into consideration the failure of the layer caused by injecting a liquid of almost the same viscosity as that of the liquid existing in the layer. The theoretical two-dimensional solutions in the theory of elasticity and theory of filtration are given (assuming the cracks as extending uniformly over the whole height of the well), and the mechanism is presented of the formation of a vertical crack under the action of mass forces corresponding to the gradients which result from the pressure applied in the well. Final formulas are given for calculating the length and the maximum width of the crack as well as the corresponding discharge for any determined difference between the pressure of the injecting liquid and the natural pressure.

An example of application is included.

R.-J. L. Bally, Roumania

2077. Shirinov, K. F., Approximate methods of solution for a (special) three-dimensional problem in the theory of filtration (in Azerb), *Uch. Zap. Azerb. Un-ta* no. 5, 21–33, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11322.

An approximate method is proposed for the solution of the problem of the inflow of liquid into an incomplete well in so far as the exposure of the stratum is concerned without inflow from the bottom. The main idea of the method is contained in the approximation of the potential or gradient of the potential on that part of the wall of the incomplete well where they are not assigned by means of trigonometrical or algebraical polynomial parts, with a factual merging of the boundary problem to the simpler boundary problems of Dirichlet-Neuman. The undetermined coefficients of the approximating polynomial parts are found, starting from some integral correlations for the potential of gradient of the potential on that part of the well where these magnitudes are assigned. The potential along the whole wall of the well is resolved into a Fourier series, the coefficients of which are expressed through the undetermined coefficients of the approximating polynomial part. The general solution of the problem, taking into account the boundary conditions for the covering, sole and external contour of the stratum, is presented in the form of a Fourier-Bessel series. The coefficients of this series are expressed through the coefficients of the approximating polynomial entities by means of comparison of this series with the Fourier series for the potential on the wall of the well. On the basis of a three-term trigonometrical approximation of the potential for one case and of a term algebraical approximation of the gradient of the potential for the other case, expressions are found for the auxiliary undimensional resistance of the incomplete well. The results of the calculation for this value are compared with the data for calculations made by the Muskat and Charnov formulas. Results are also given for the calculation of the potential on the wall of the well and for their comparison with the value (assigned) of the potential on the opened up part of the well. The comparison testifies to the effectiveness of the method.

A. L. Khein

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2078. Zhautykov, O. A., Relating to the solution of a single problem in the theory of filtration (in Russian), *Izv. Akad. Nauk KazSSR, Ser. Matem. i Mekhan.* no. 6(10), 46–50, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12901.

The problem is investigated [O. A. Khautykov, *Izv. AN. Kaz. SSR. Ser. matem. i mekhan.*, 1956, (4), 70–79—*R. Zh. Mekh.*, 1957, (7), 8101] on the distribution of the pressure in an elastic stratum after the sudden stoppage of the functioning of the deep-level pump, if the liquid still continuing to flow to the well goes toward the raising of the dynamic level, that is to say increases the pressure on the face. The solution of the equation of heat conductivity

$$\frac{\partial^2 p}{\partial r^2} + \frac{1}{r}\frac{\partial p}{\partial r} = \frac{1}{a^2}\frac{\partial p}{\partial t}, \qquad K \leqslant r \leqslant R_k,\ t \geqslant 0$$

with the conditions

$$p(r, 0) = \varphi(r) \qquad \text{with } R \leqslant r \leqslant K_k$$

$$p(R_k, t) = p_k = \text{const} \qquad \text{with } t \geqslant 0$$

$$\left(\frac{\partial p}{\partial r}\right)_{r=R} = \gamma \left(\frac{\partial p}{\partial t}\right)_{r=R} \qquad \text{with } t \geqslant 0$$

(where γ is a constant number, R is the radius of the well) is sought in the form $p(r, t) = u(r, t) + \varphi(r)$, the Laplace conversion being used in the process. An image is found for the function $u(r, t)$; however in the course of transition to $u(r, t)$ author does not explore the existence of the roots of the multiterm Bessel function which enters the calculation in the form of a multiplier and denominator of the sub-integral expression of the Fourier-Mellin formulas of conversion, that is to say the presence is not investigated of supplementary poles. Consequently the problem set cannot be considered completely solved, or the final result substantiated.

V. N. Nikolaevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2079. Trofimenkov, Yu. G., Calculation of imperfect wells during unpressurized filtration (in Russian), *Gidrotekh. Stroit.* no. 11, 39–43, 1956; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12894.

The paper is a summary of the author's dissertation for his degree ["Calculation of perfect and imperfect wells with portions emptied," Nauchn. Issled. In-ta Osnovanii i Fundamentov, 1953] and repeats almost word for word his previous paper [In: "Experiments on the artificial reduction in level of subterranean soil water when building hydroelectric stations, Moscow-Leningrad, Gosenergoizdat, 1956]. The author gives approximate formulas for the calculation of the magnitude of the portion being emptied, for the ordinates of the depression curve and the output of individual complete and incomplete wells, all with reference to a flow with a free surface. The structure of these formulas is based on some theoretical concepts advanced by N. N. Shepelevskii ["The hydromechanical calculations for some hydrotechnical installations," Dissertation, 1943]. Their final form was determined in accordance with experiments carried out by the EGDA method. For the calculations for the emptying portions and the discharge of interacting wells the author uses the same formulas, inserting into them the "interference coefficient," representing in itself the relation of the emptying portions or discharges of interacting and single wells. The magnitude of this coefficient is determined from the known solutions for various systems (contours) of interacting wells with corresponding conditions on the contour of the stratum. In fact "the interference coefficient" is the indicator of the relation of "the hydraulic resistances" for single and interacting wells.

F. M. Bochever

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2080. McEwen, C. R., A numerical solution of the linear displacement equation with capillary pressure, *J. Petroleum Technol.* **11,** 8, 45–48 (Technical Note), Aug. 1959.

Author uses displacement equation of water and oil in porous media, developed by Buckley and Leverett [*Trans. AIME*, **146,** p. 107, 1942] by applying the equation of continuity to the one-dimensional flow of two incompressible fluids. In computing saturation-versus-distance curves, effect of capillarity has been taken into account, but with the gravity term omitted. No outlet

end-effect is considered and there is no flow of water ahead of the flood front. Saturation may be computed with successive numerical approximations, taking equal time intervals. As examples, developments of saturation profiles are presented which agree qualitatively with published data. At high rates, the computed behavior approaches that predicted by the Buckley-Leverett method. A. Kezdi, Hungary

2081. Hutchinson, T. S., and Sikora, V. J., A generalized water-drive analysis, *J. Petroleum Technol.* **11,** 7, 169–177, July 1959.

Paper presents a method for making a water-drive analysis without prior knowledge of aquifer geometry and uniformity, using a standard desk calculator. Equation is developed which relates pressure at the water-oil contact to the water influx rate as a function of time by a factor called the resistance function which introduces the composite effect of the aquifer geometry and flow resistance distribution. The characteristic shape of this function makes it possible to start with an approximation and successively improve it until the correct function is obtained. Water-drive estimates can be made without simplifying aquifer shapes and flow distributions. Methods are given for extrapolating the final curve to calculate future aquifer behavior. Equations are developed for adjusting the pressures and water influx rates in the case of possible errors. The pressure build-up analysis technique is used to estimate some of the aquifer properties.

From authors' summary by A. Kezdi, Hungary

2082. Murav'ev, I. M., Shurov, V. I., and Shanpin, Go, The effectiveness of the hydraulic rupture of a stratum (in Russian), *Neft. Kb.-vo* no. 12, 32–41, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11343.

An investigation was made on electrolytical models of the inflow of liquid to a well with cracks, which were produced in the stratum as the result of hydraulic rupture. Authors examine the case where the relation of the permeability of the crack to the permeability of the stratum is $\sim 10^9$, that is cracks were modelled whose permeability could be looked upon as infinitely great in comparison with the permeability of the stratum. In the experiments a determination was carried out of the relation of output η of a well with a single or several cracks to the output of a complete well and also of the nondimensional coefficients

$$C = \frac{\eta - 1}{\eta} \ln \frac{R_k}{R_c}$$

where R_k is the radius of the feed contous, R_c the radius of the well. Studies were made of the relations of values C or η to the radius of a horizontal crack, to the location of the crack, to the power exercised by the stratum, to the number of horizontal cracks, the relation of the permeability of the stratum in the vertical direction to the permeability of the stratum in the radial direction, the dip of the horizontal crack and also the heights of the vertical crack. Results of the experiments are recorded in tables and graphs. Yu. P. Zheltov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2083. Baranovskaya, N. N., Some remarks on the break-through of water from pressure wells to the workings of a rectilinear alternating battery (in Russian), *Izv. Vyssh. Uchebn. Zavedenii, Neft'i Gaz.* no. 1, 87–94, 1958; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11344.

The process is investigated of the break-through of water from pressure wells to the workings of an intersecting battery on the assumption that differences of viscosity, specific weights and permeabilities of the petroleum and the water do not exist. It is shown that the problem is solvable by the method of sources and sinks. Deductions are not forthcoming from the formulas recorded for the velocity of filtration, nor are there formulas for finding points where the velocity of filtration is equal to zero. However, on the basis of analysis of the recorded formulas, the deduction is made that the most rational method for conversion of the intersecting battery to a complete pressure unit would be to follow this procedure: first of all it would be necessary to obtain a much larger output from the pressure wells up to the point where the front of the water reaches half the distance between the wells; having accomplished this, it is essential to increase the yield of the working wells while conserving the output of the pressure wells. An examination is made of the influence exercised by the presence of working rows of wells on the flooding of the intersecting row. Examples of the calculations are given.

V. N. Nikolaevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2084. Mikhailov, G. K., On two approximate methods in the theory of non-uniform ground-water flow along a plane impermeable base, Proc. 3rd Congr. Theor. Appl. Mech., Bangalore, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1957; 175–188.

Author proposes to investigate the problems of two-dimensional ground-water motion, both steady and unsteady, in the isotropic medium with a plane impermeable base with the artifice of imposing the anisotropy of permeability perpendicular to the impermeable base, the characteristics of the anisotropy being either of the following:

(1) The coefficient of permeability along the axis of anisotropy is zero. Consequently all streamlines would be located in planes parallel to the impermeable base.

(2) The coefficient of permeability along the axis of anisotropy is infinity. Consequently the flow would encounter no resistance when moving vertically and, therefore, v_s would rigorously be equal to v_x.

All the naturally selected characteristics of the corresponding flow in isotropic medium are supposed to be between the values of characteristics obtained in those two cases of anisotropy, and this assumption is verified in the problem of steady seepage through a trapezoidal dam with a vertical upstream slope and in that of an unsteady spreading of ground water in the initially dry ground with a horizontal impermeable base.

The proposed method is extended further to the case of nonlinear seepage. T. Hayashi, Japan

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 1625, 1723, 1726, 1733, 1821, 1823, 1898, 2045

2085. Takeuchi, H., General solutions of equations of some geophysical importance, *Bull. Seismol. Soc. Amer.* **49,** 3, 273–283, July 1959.

A method is presented by which the theory of elasticity, the mechanics of a viscous incompressible fluid, and the electromagnetic theory can be investigated in a unified way. General solutions are obtained in rectangular, circular cylindrical and spherical coordinates for the equations of motion of a homogeneous isotropic elastic body, Maxwell's equations for a homogeneous isotropic conductor, and so on. The solutions in spherical coordinates, for example, are obtained without transforming the fundamental equation into the spherical coordinates as long as possible. This makes the mathematics in this paper easily understandable. Some of the results are not new [cf. N. A. Haskell, *Physics* **6,** p. 265, 1935;

p. 56, 1936; K. Sezawa, *Bull. Earthq. Res. Inst.* **2**, p. 13, 1927; J. A. Stratton, "Electromagnetic theory," 1941, pp. 360, 414; K. Terasawa, *J. Colloid Sci., Imperial Univ. Tokyo* **37**, p. 64, 1916] but some of them were recently introduced.

Y. Sato, Japan

2086. Eaton, J. P., and Takasaki, K. J., Seismological interpretation of earthquake-induced water-level fluctuations in wells, *Bull. Seismol. Soc. Amer.* **49**, 3, 227–245, July 1959.

Magnitudes for normal-depth earthquakes computed from the amplitude of water-level fluctuations induced in a well tapping a confined aquifer in Honolulu, Hawaii, agree closely with those assigned by Pasadena. The maximum fluctuations in the well are produced by long-period Rayleigh surface waves. The response of the well to earthquake waves diminishes rapidly as wavelength decreases.

From authors' summary

2087. Kolossvary, B. G., Eötvös balance, *Amer. J. Phys.* **27**, 5, 336–343, May 1959.

Application of potential, equipotential surfaces, and related concepts is more readily obtained on college level through the discussion of the theory and operation of the Eötvös balance. Description of the different kinds of balances suitable for various gravity measurements, the physical interpretation and measurement of the second partial derivatives of the potential function, as well as some experiments for advanced college students, are discussed.

From author's summary

2088. Napetvaridze, Sh. G., Questions dealing with the stability to seismic disturbance of constructions of the supporting wall type (in Russian), *Trudi In-ta Stroit. dela Akad. Nauk GruzSSR* **6**, 59–76, 1957; *Ref. Zh. Mekh.* no. 10, 1958, Rev. 11584.

Methods available for evaluating the effect of earthquakes are given for use when designing constructions of the supporting walls type and recommendations are made to ensure the seismic-proof nature of such structures. By analyzing the reciprocal action of a supporting wall with the filler and taking into account the pliancy of the foundation's soil, author reaches the conclusion that the seismic load on the wall will continue to increase up to the point where the foundation's soil will practically be unable to acquire the property of incompressibility of the medium and, consequently, will not cease its effort to overturn the wall at the expense of its pliability. From this moment the usual calculation formulas are correct when dealing with active and passive pressures of the filler in seismic swaying with the difference that instead of ε in the corresponding formulas the total angle of inclination of the back wall $\varepsilon_c = \varepsilon + \Delta_\varepsilon$ will figure; here Δ_ε is the magnitude of the angle for the overturning of the wall at the expense of the pliability of the foundation's soil. The influence of the "give" of the foundation on the size of the thrust with a seismic disturbance rating of 9 points ($\Delta_\varepsilon = 5°$) shows itself in the increase of the effect of seismic action by nearly two times (increases of the force of the earthquake of approximately 1 point).

Author continues by investigating the influence on the seismic-resistant properties of supporting walls, their constructional characteristics and the special conditions of work of some forms of construction; he makes further recommendations on the adoption of antiseismic measures of a constructional and building nature. The following antiseismic measures should be insisted on for the construction of supporting walls in modern hydrotechnical installations: (1) soils for filling up should possess a large angle of friction; (2) establishment of thermally settling junctions combined with seismic ones; (3) passing from one point of the foundation to another by means of ledges to meet the case of a sharp change in the depth of the laying of the foundations along the wall; (4) imparting to the backface of the wall of a slope to the side of the filling; (5) the adoption of grooved and box-type walls. To neutralize the influence on the seismic stability of the supporting wall of the pliability of the foundation a recommendation is made to extend the foundation of the wall to the rocky or semi-rocky level in the soil or to undertake the artificial strengthening of a weak foundation. With the same objectives in view, a significant widening of the wall's foundation is suggested. The use of pile foundations is not advised for regions subject to 9-point seismic disturbance, nor in sandy soils where there is every likelihood of intensive vibrosinking of the piles.

A. I. Govyadinov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2089. Welander, P., On the frequency response of some different models describing the transient exchange of matter between the atmosphere and the sea, *Tellus* **11**, 3, 348–354, Aug. 1959.

A theoretical study is made of the response characteristics of two "box-models" and two continuous models of the sea which could describe an air-sea exchange of matters. It is demonstrated quantitatively that the box-model can depict a transient exchange process correctly only when the time of internal mixing of the sea is small compared to a certain "transfer time." Comparing the two continuous models studied, one of which assumes a purely diffusive sea and the other a purely advective sea, one finds some interesting differences in the response characteristics.

From author's summary by M. S. Weinstein, USA

2090. Dobryshman, E. M., Some problems in humidity variations in large-scale processes (in Russian), *Trudi Tsentr. In-ta Prognozov* no. 60, 32–36, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12800.

The influence is studied of different factors on the changes in humidity content in the atmosphere and a method is proposed for long-term rain forecasts. To begin with the question is investigated of the formation of a zonal field of humidity. It is accepted that the zonal distribution of water vapor in the troposphere is determined by the turbulent mixing both in the horizontal and in the vertical directions, and also by the presence of "discharges" of humidity representing the sum total of the precipitations (rainfall). The solution is sought in the form of a series with the usual Legendre polynomes with coefficients depending on the height (altitude). The results of the calculation made according to the formulas obtained agree quite well with the factual data. It is established that the zonal distribution of humidity is expressed to a good approximation by the formula $\tau(\tau, \theta) = N(z) + M(z)\sin^2\theta$, where τ is the dewpoint, z the vertical coordinate, θ the complement to the latitude. To continue, a method of prognosis for the humidity is put forward. The starting point here is the equation describing the changes of humidity due to its transmission by the velocity field. This equation is linearized relative to the zonal fields of velocity and humidity. The meridional and vertical components of velocity are determined by the scheme evolved by E. N. Blinov. The solution obtained was used for forecasting mean-month anomalies. A comparison is made between the mean-monthly fields of vertical flows and humidity and the factual anomalies of precipitations. It is shown that the humidity predicted agrees better with the precipitation anomaly than does the prediction for the vertical currents.

S. A. Mashkovich

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2091. Peperpelkina, A. V., A few results of the investigation of the turbulent pulsations of the temperature and the vertical component of the wind's velocity (in Russian), *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 6, 765–778, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12845.

Results are given for the investigations carried out on the turbulent pulsations of a temperature T_1, the horizontal and vertical velocities u' and w' in the earth's surface layer of the atmosphere; these investigations were made on apparatus of low inertia, developed in the geophysical institute of the Academy of Science of the

USSR. These measurements were accompanied by observations on the gradients, which consisted in the recording of the mean velocity of the wind at level of 0.5, 1, 2, 5, 9 and 15 m and the differences of temperature at a level of 2 m and some of the other levels mentioned. On the basis of the data for the gradient observations a determination was made of value $B = (T_1 - T_4)/V_2^2$ (T is the temperature, V is the wind's velocity, index is the height measured in meters) and also by means of the formulas of the theory evolved by A. S. Monin and A. M. Obukhov [*Trudi Geofiz. In-ta* no. 24, 163–187, 1954] of the dynamic velocity V_* and the parameter L introduced into this theory. A comparison of the statistical characteristics of the turbulent pulsations T' and w' with the recalculated characteristics of the mean state enabled several deductions to be drawn. The mean quadratic value $T_1(\sigma_t)$ at a height of 1.7 m is linked up with the difference $T_1 - T_4$ by means of an empirical relation having different forms for the unstable stratification ($T_1 > T_4$) and the stable ($T_1 < T_4$).

$$\sigma_t = 0.54(T_1 - T_4) \qquad (T_1 > T_4) \qquad [4]$$

$$\sigma_t = -0.08(T_1 - T_4) \qquad (T_1 < T_4) \qquad [5]$$

With $T_1 - T_4 = 0$, σ_t is very small. The mean quadratic value of $w'(\sigma_w)$ is closely linked (with a correlational coefficient of 0.96) with the dynamic velocity v_*. The corresponding relations have the form of

$$\sigma_w = 0.86v \qquad z = 1.7 \text{ m}$$

$$\sigma_w = 0.82v \qquad z = 15 \text{ m} \qquad [8]$$

(z is the height). The dynamic velocity is also determined from the data of the pulsations of the horizontal and vertical components of velocity by means of the formula

$$v_*^2 = -\overline{u'w'} \qquad [10]$$

(the line indicates an averaged value). The values of v_* determined by formula [10] proved to be 18% less, on average, than when calculated by the gradient data, when the correlation between the values of v_*, calculated by these two independent methods, is ascertained by using the coefficient 0.90. Using the data obtained from the pulsation measurements the structural function of periodic temperature was determined

$$H(\tau) = \overline{[T'(t+\tau) - T'(t)]^2} \qquad [11]$$

which could be approximated by means of the stepped principle

$$H(\tau) = H(1)\tau^{2\alpha} \qquad [14]$$

Function ($H\tau$) was brought to the three-dimensional structural function

$$H(\tau) = \sigma_{\Delta T}^2(r); \qquad r = V\tau$$

on the basis of the hypothesis of transfer of pulsations by the central flow. It is explained that in the interval of 0.2 sec $< \tau <$ 15 sec (0.7 m $< r <$ 41 m) this function's approximation with the single step principle is not good. That is to say, when τ values are small the exponent is close to the theoretical value of 0.33, while with increase of τ this goes down to 0.20. In place of the structural function for w a determination was made for a normalized autocorrelational function

$$R(\tau) = \frac{\overline{w'(t+\tau)w'(t)}}{\sigma_w^2} \qquad [16]$$

This function rapidly drops from unity when $\tau = 0$ to zero and to small negative values with τ of the order of seconds. The paper concludes with an investigation of the influence exercised by an increase in the inertia of the apparatus, that is, the smoothing down of the initial pulsations to the statistical characteristics of turbulence. It was shown that by increasing the smoothing down interval from 0.1 to 1.6 secs the turbulent flow of heat is reduced by approximately twice as much. This indicates that at least half the turbulent flow of heat is explained by high frequency turbulent pulsations with a period of less than 2 secs.

L. S. Gandin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2092. Sasaki, Y., A numerical experiment of squall-line formation, *J. Meteorol.* **16,** 4, 347–353, Aug. 1959.

The formation of a prefrontal squall line is studied, based on a numerical method of solving the so-called "primitive" equation of "two-dimensional" motion, continuity (mass and "moisture" content), and thermodynamics simultaneously. Due to the limited capacity of the electronic computer used (IBM 650), computations in this numerical experiment are necessarily simplified and are merely for the incipient stage of squall-line formation. The study is made for two idealized cases, both of which consider conditions in advance of an intense cold front. From results obtained, it is shown that a significant factor for squall-line formation is the ageostrophic flow represented by unbalance between thermal wind and actual wind shear. Also, the role of a strong southerly flow at low levels is indirect and appears to be that of supplying moisture from ocean area. Reviewer believes that the internal gravity waves derived here could be questionable because of the limited steps of computation (1 hr in nature time), although this result is highly valuable.

H. Arakawa, Japan

2093. Suzuki, E., Weather forecast and entropy in information theory, *Pap. Meteorol. Geophys.* **9,** 2, 51–62, Dec. 1958.

Author tries to introduce the idea of entropy in information theory to the various problems of weather and forecasting and show systematic correlation between the ideas of relative entropy and transmitted amount of information in information theory.

A simplified method for estimating correlation coefficients is offered, and an effective procedure for weather forecasting under several restricting conditions based on the principle of maximum total entropies is given.

Lastly, hypothetical examples of the procedure are schematically shown for the daily temperature forecasting, etc.

From author's summary

Naval Architecture and Marine Engineering

(See also Rev. 1799)

2094. Nishiyama, T., Hydrodynamical investigation on the submerged hydrofoil, Part I, *J. Amer. Soc. Nav. Engrs.* **70,** 3, 559–567, Aug. 1958.

Author presents solution of direct problem of determining lift, wave resistance and pressure distribution on two-dimensional hydrofoil. Solution takes into account the influence of the free surface wave motion on the normal velocity condition on the foil boundary. Expressions are given in the form of infinite series in terms of chord Froude number. Practical applications require Fourier series coefficients of hydrofoil section shape, from which various required functions are obtained. A table of required quantities, dependent on submergence Froude number but independent of the foil shape, is presented to facilitate numerical calculations. Numerical calculations for the NACA 4412 section are made and compared with previous results of approximate theory as well as with experiments. Agreement between present theory and experiment is shown for range of submergence beyond region where extraneous effects such as hydraulic jump occur.

P. Kaplan, USA

2095. Nishiyama, T., Hydrodynamic investigation of the submerged hydrofoil, Part II, *J. Amer. Soc. Nav. Engrs.* **70**, 4, 663–668, Nov. 1958.

Author presents solution of indirect problem of determining hydrofoil shape from prescribed pressure distribution, including effects of the free surface. Method utilizes successive approximations, with second approximation sufficient to produce final profile shape. First approximation assumes a flat plate, and velocity distribution in infinite fluid and near free surface for the plate is used as first approximation of actual foil, giving equivalent infinite fluid velocity field. The foil shape for this distribution is computed by standard aerodynamic procedures.

The change in velocity distribution due to the free surface, for the foil shape that is found by the first approximation, is found by application of the author's previous work [see preceding review]. A similar procedure for finding the infinite fluid velocity distribution and the resulting foil shape is followed, as in the first-approximation procedure.

Numerical examples are presented for three different pressure distributions. It is shown that calculation of the profile form, neglecting the influence of the free surface, will result in a smaller lift coefficient when operating below a free surface than the value originally specified for the given pressure distribution. Another result obtained from this study is that a pressure distribution should only be chosen for the purposes of avoiding cavitation and reducing drag losses due to friction and boundary-layer separation. The wave resistance appears to be insensitive to the type of pressure distribution, as long as the lift coefficient remains constant.

All of the results obtained are based on two-dimensional flow. It is assumed that these conclusions can be carried over to hydrofoils of finite aspect ratio. P. Kaplan, USA

2096. Newman, J. N., The damping and wave resistance of a pitching and heaving ship, *J. Ship. Res.* **3**, 1, 1–19, June 1959.

The so-called energy method is used to evaluate the damping and wave resistance coefficients of a thin ship moving in calm water with constant velocity and oscillating in pitch and heave. The perturbation potential is expanded in terms of two parameters: the beam-length ratio [see Stoker, AMR **11** (1958), Rev. 2903] and the oscillation amplitude. Introduction of the second parameter removes the disadvantage of Stoker's treatment where expansions are performed with respect to the beam-length-ratio parameter alone.

Calculations are presented for a model of beam-length ratio 0.118 and draft-length ratio 0.047 at various Froude numbers from zero to 0.36. Comparison of pitch and heave damping coefficients with Golovato's [AMR **11** (1958), Rev. 714] experimental results are somewhat unsatisfactory; the potential theory giving significantly *higher* values. This is somewhat disturbing since viscous effects presumably would modify the theoretical results in the wrong direction, by increasing the damping. The Golovato experiments are considered reliable and therefore author's linearization processes might not be applicable for the example presented.
V. G. Szebehely, USA

2097. Karakashev, V. A., Investigation of the ballistic error in the sensitive elements of gyroscopic recording instruments, recording the pitch and roll of a ship (in Russian), Avtorefer. Diss. Kand. Tekhn. Nauk, Leningr. In-ta Technoi Mekhan. i Optiki, Lengingrad, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6306.

2098. Raghuram, T. S., The application of wave profile calculations to hull forms comprising a breadth/draft variation series, Proc. 2nd Congr. Theor. Appl. Mech., New Delhi, India; Indian Soc. Theor. Appl. Mech., Indian Inst. Technol., Kharagpur, 1956; 165–186.

Calculations are made of the wave profile for a ship of minesweeper form using (a) Havelock's method of sources and sinks and (b) Guilloton's method of parabolic wedges. The results are compared with the wave profile photographed in model tests. The results obtained by the two calculation methods do not agree and neither method agrees with the test results. The test results tend to give higher bow waves and lower stern waves than calculated. The author lays the discrepancies in the bow wave to the difficulties of adequately representing the hull form by mathematical relations—the two computed results, although applied to the same hull, actually represent the wave patterns for different forms because of the representation difficulty. The difference in height of stern wave he attributes to the viscous effects that are neglected. F. E. Reed, USA

2099. Horn, F., and Walinski, E. A., Investigation of the maneuverability and stability of the course of ships (in German), *Schiffstechnik* **5**, 29, 173–190, Nov. 1958.

2100. Semenov-Tyan-Shanskii, V. V., Diagram of the static stability of a ship taking into account a fluctuating differential (in Russian), *Trudi Nauchno-Tekhn. O-va Sudostroit. Prom-sti* **7**, 2, 161–170, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12679.

Because of the unsymmetrical form of the forward and aft ends of the ship relative to the plane of the amidship's frame when the ship rolls to an angle of θ, a re-establishing moment is produced in the longitudinal plane, normal to the plane of the effective waterline. This re-establishing moment gives rise to a differential for the ship, measured by the angle ψ. Even with large values for θ, the value of ψ is relatively small; consequently, when calculating the stability at large angles of heeling, it is usual to take ψ as being a constant and the action of the longitudinal moment is not taken into account. With the object of introducing an improvement into the calculations for the diagram of the statical stability of the ship a formula is proposed, enabling calculations to be made for changes in the angle of the differential ψ and in the transverse re-established moment when heeling over to a large angle θ, an external moment impeding a change in the angle ψ being absent. In deducing the formulas, use was made of the construction of a "Chebyshev" framework, the determination of the ingoing and outgoing coordinates of the waterline by means of the Krylov-Darnier method, and of mathematical instruments applicable for the measurement of small angular motions of ships. A method is given, as well as calculations in tabular form, for the static moments of volumes, for the moments of inertia of the projections of the waterline planes, for the re-establishing moments, for the corrected moments of static stability and the differential's angles. It was shown that only a big mass of accumulated calculation data would serve to establish the accuracy of the proposed method when large angles of heeling were concerned. V. B. Dragomiretskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2101. Machabeli, L. I., Parametric resonance during pitching and rolling of a ship (in Russian), Avtoref. Diss. Kand. Tekhn. Nauk, Leningr. Korablestroit. In-ta, Riga, 1957; *Ref. Zh. Mekh.* no. 6, 1958, Rev. 6723.

2102. Tachmindji, A. J., and McGoldrick, R. T., Note on propeller-excited hull vibrations, *J. Ship Res.* **3**, 1, 28–35, June 1959.

Article gives curves of free field propeller-generated pressures measured on a model as a function of axial distance from propeller, the radial distance over the propeller blade tip and the number of blades. It gives curves showing computed forces and moments generated at the propeller by irregularities in wake for two displacements of a single-screw ship. It discusses the calculation of natural frequencies and natural modes of vibration of a hull and

the forced response of the hull to propeller excitation. It gives approximate empirical formulas for estimating the amplitudes at the stem of vertical, horizontal and torsional vibrations of high frequency. It discusses damping and the amplitudes of resonant vibrations in the normal hull bending modes.

Although there is much information that must still be developed before hull vibration can be predicted accurately, this excellent paper summarizes the developments made in this field in recent years and gives experimental data and calculation procedures that can be a help to anyone trying to avoid hull vibration.

F. E. Reed, USA

Friction, Lubrication and Wear

2103. Tarao, K., On the wear of an alloy cast iron cylinder liner, *Bull. JSME* **2**, 6, 230–237, May 1959.

The cylinder liner materials were tested for the reduction of wear in high-speed diesel engine. The test cylinder liner containing Mo and Cu was cast by centrifugal casting. Addition of 0.65% Mo and 2.0% Cu was the most suitable, and through this the wear was reduced to 76% of the liner used hitherto. Author made precision measurement of the liner wear in relation to the running kilometers and could make evident the profile of the liner wear that was different from the typical one when chromium plating ring was adopted as the top ring.

The author surmises that the structural change of matrix might be effective for improvement of wear resistance and suggests that for liner materials, attention should be paid not only to the properties of casting state but also to the hardenability and other properties at elevated temperature for cylinder wear.

From author's summary

2104. Bartenev, G. M., and Lavrent'ev, V. V., On the law of friction for highly elastic materials (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 126–129, Sept. 1958.

Experiments confirming the formula for friction force between a rubber sample and aluminum or steel plate are discussed. Short discussion of empiric formulas of others is given.

Z. Olesiak, Poland

2105. Blekhman, I. I., and Dzhanelidze, G. Yu., On effective coefficients of friction for vibrations (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 98–101, July 1958.

Paper deals with an investigation relative to the coefficient of friction under the effect of vibrations. Different cases are studied, namely (a) when the sinusoidally varying force is parallel to the supporting surface, (b) when it is perpendicular to this surface. A uniformly accelerated motion is also studied in two cases: (c) sinusoidal force Φ has the same direction as the force S producing the motion, and (d) when the force Φ is at right angles to the surface. In all calculations it is assumed that the coefficient of friction at rest is determined by the relation $f_1 = S_{1\,min}/N$, where $S_{1\,min}$ is the lower limit of force required to produce the motion from the state of rest and N is the normal reaction.

A number of conclusions are obtained, namely (1) the coefficient of friction decreases with the increase of amplitude Φ_0 and becomes zero for a critical value of Φ_0; the values of the force f for which this happens are different for the above-mentioned cases; (2) the classical coefficient of friction is normally greater than the coefficient of friction with superimposed vibration but for larger values of Φ_0/N the opposite effect takes place, and a number of similar conclusions.

The paper ends with a discussion of these various results.

N. Minorsky, France

2106. Galeev, A. U., and Pershits, Yu. I., Features of slip friction during the movement of a body over an anisotropic surface (in Russian), *Trudi Mosk. In-ta Inzh. Zh.-d. Transp.* no. 92/11, 169–180, 1957; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12156.

The material difference is pointed out, citing a number of cases, in the coefficients of friction of a surface in the direction of its workings and in other directions. In conjunction with this the problem is propounded and investigated, in its general qualitative form, on the friction of a material point with the surface possessing anisotropic frictional characteristics. Authors introduce a polar curve to indicate the dependence of the specific work of the force of friction on the direction, as an example of the basic characteristics of the frictional properties of the surface. For the purpose of making some evaluational calculations they treat this curve as an ellipse; however, the investigation, in the main, remains unaltered whatever the form of the curve. The paper continues with the drawing of the curve of the specific work, using the same scale, acting on a point of the force in relation to direction, which can be represented as a surrounding region built on the vector of the acting force as well as on the diameter. Here the motion can take place in directions in which the second curve extends beyond the limits of the first, and which, in the authors' view, actually does so in the direction in which the difference between the radii-vectors of both curves attains its maximum. In the abstractor's opinion, the selection of the direction of the actual motion lacks sufficient confirmation. In this way the conclusion is reached that the direction of the motion does not coincide, generally speaking, with the direction of the applied force. Assuming that the curve of specific work of the force of friction is an ellipse, authors find the angle between the motion's direction and the direction of the acting force. To conclude the paper the construction of a cone of friction for an anisotropic surface is investigated.

G. I. Barenblatt

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2107. Davydov, B. L., and Chzhou, S.-y., A more accurate definition of the theory of friction of flexible bodies (in Russian), *Vestn. Mashinostroeniya* no. 2, 16–19, 1958; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 12157.

An investigation is made of the relationship between the tensions of a portion of a ribbon running onto a pulley and running off a pulley. The investigation is carried out for a flexible ribbon when taking changes in its thickness into account, and for a ribbon reinforced along the line of axis by means of small steel ropes. In the last case the model of shear is taken to be constant and the model of elasticity infinitely large. Comparing the obtained results with the known N. E. Zhukovskii formulas deduced for an unelongated ribbon, authors come to the conclusion that for an elastic ribbon of appreciable thickness, and for a reinforced ribbon, any attempt to treat it as inextensible leads to significant error.

G. K. Pozharitskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2108. Rudyakov, Z. Z., The rolling of cylindrical bodies taking into account the friction forces of cohesion (in Russian), *Trudi Dnepropetr. In-ta Inzh. Zh.-d. Transp.* no. 26, 322–335, 1958; *Ref. Zh. Mekh.* no. 11, 1958, Rev. 13003.

The plane problem is examined of the rolling of an elastic cylindrical body on an elastic base. Here, as also in the work of N. I. Glagolev [*Prikl. Mat. Mekh.* no. 9, 1945], it is assumed that the line of contact consists of one part of cohesion and two parts of slip. However, differing from the work cited, the author recommends the adoption of a coefficient for the slip friction lower by two times to the coefficient of cohesion friction and furnishes an experimental curve to confirm this relationship. When deducing

the calculation relations, author uses the results obtained by N. I. Muskhelishvili [Some basic problems in the mathematical theory of elasticity, Izd-vo, Akad. Nauk SSSR, 1954]. While examining the expression for the tension forces, author refers to their characteristics distinguishing them from those previously known and shows that for all locomotives the maximum force for the pull will be attained when the relation of the length of the portion of cohesion to the length of the portion of contact is equal to 0.3. An experimental relation is given for the area of contact and magnitude of the small axis of the ellipse to the pressure of the wheel on the rail, and also a table which contains the coefficients required for the calculations.

A. V. Shlyakhtin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—2109. Popovich, M., and Hering, C., Fuels and lubricants, New York, John Wiley & Sons, Inc., 1959, vii + 312 pp. $8.50.

Book devotes five chapters to general topics: introduction, calorimetry and heating value calculations, organic chemistry, crude oil, and petroleum refining; six chapters to fuels: solid fuels, gaseous fuels, gasoline, distillate and residual fuels, rocket propellants, and nuclear fuels; and two chapters to lubricants: lubricating oils, and greases and solid lubricants. Book covers a wide field. Text material is up-to-date; presentation is orderly and clear. Chief emphasis is on standard test methods, and great reliance is placed on ASTM Standards, Federal Test Method Standard No. 791 and several military specifications. An attempt is made to explain significance of standard test methods, and authors have done so competently, considering difficulty of this task. Otherwise, treatment is descriptive, elementary and rather superficial. A small but carefully selected list of references is appended to each chapter for those wishing to pursue further.

P. M. Ku, USA

2110. Sasaki, T., Okino, N., and Fujita, T., Lubrication of high-speed tapered roller bearing by atomized oil, *Bull. JSME* **2,** 6, 223–229, May 1959.

In this report, the operating characteristics and the mechanism of lubrication of high-speed tapered roller bearing under lubrication by atomized oil, i.e. oil-fog lubrication, are investigated experimentally and theoretically.

From the experimental results on the influence of oil supply, air supply, viscosity of oil, load and rotating speed, it has been clarified that the lubrication by atomized oil lessens remarkably the friction and the temperature rise in the suitable condition and the atomized oil lubricates mainly as hydrodynamical lubrication.

Based on these characteristics, the hydrodynamical theory concerning the frictional moment and temperature rise of tapered roller bearing has been deduced, and it is confirmed that this theory coincides with the results of experiments moderately well.

From authors' summary

2111. Gross, W. A., A gas film lubrication study, Part I: Some theoretical analyses of slider bearings, *IBM J. Res. Devel.* **3,** 3, 237–255, July 1959.

The general differential equation governing hydrodynamic lubrication with a compressible, laminar isotropic Newtonian fluid is developed. This equation may be reduced to the well-known Reynolds equation applying to incompressible lubricating liquids by dropping density terms. However, the interest here being gas lubrication, the author combines the pressure, energy, state and pressure-density relations to derive a general pressure distribution equation for gases involving the polytropic gas exponent. W. J. Harrison previously solved the differential equation by assuming an infinitely long bearing and a film thickness linearly varying with distance in the direction of flow.

Gross, however, proceeds to solve the equation on a digital computer using the finite-difference technique. Numerous families of pressure distribution, center of pressure location and load-capacity curves are presented relating many of the parameters involved for plane, cylindrical and spherical infinitely long bearing surfaces and for isothermal as well as adiabatic conditions. Thus data needed to easily design theoretical air-lubricated slider-bearings are made available.

J. P. Vidosic, USA

2112. Michael, W. A., A gas film lubrication study, Part 2: Numerical solution of the Reynolds equation for finite slider bearings, *IBM J. Res. Devel.* **3,** 3, 256–259, July 1959.

The Reynolds pressure equation cannot be solved in closed form for finite, gas-lubricated slider bearings. Recourse is therefore made to an approximate numerical solution. This is commenced by assuming viscosity independent of X and Y coordinates over a rectangular region representing one-quarter of the bearing surface (symmetry in geometry and thus pressure function). Indicated differentiations in Reynolds equation are performed and boundary conditions applied to the quarter section. The pressure function is then expanded into a Taylor series and a finite difference approximation to the pressure equation obtained. Terms involving higher derivatives are omitted. The simplified pressure function is then numerically solved by the single-step iterative "extrapolated Liebman" method, in which the net is traversed in a fixed sequence with old values replaced by new ones as obtained. The iteration is continued until the "convergence indicator" becomes sufficiently small.

This is programmed for the IBM-650 computer, which traverses the plane for convergence until the equilibrium angle (pivot coincides with pressure center) for a pivoted slider is obtained. The load is then computed and its value along with the correct angle punched on cards.

J. P. Vidosic, USA

2113. Brunner, R. K., Harker, J. M., Haughton, K. E., and Osterlund, A. G., A gas film lubrication study, Part 3: Experimental investigation of pivoted slider bearings, *IBM J. Res. Devel.* **3,** 260–274, July 1959.

Various parameters affecting the performance of air-lubricated slider bearings were investigated experimentally and compared with approximate numerical solutions. Pivoted flat surface bearings proved unstable. The wedge-effect with air as the lubricant apparently is too weak to support much of a load. The wedge was thus magnified by investigating a cylindrical convex surface slider. This improved significantly the stability and increased load-carrying ability considerably. Maximum load capacity for a given film thickness was obtained at a crown height (chord to curve) of around 350 microinches. For a given minimum film thickness the angle of inclination was also found to increase with crown height. Speed tests indicated the film-thickness variation with speed for a given load is nearly linear. These results were compared with computer data and reasonably good agreement found. Isothermal flow conditions proved a little closer than adiabatic.

The manufacture of convex surfaces, the measurement of film thicknesses and of slider curvature are described in appendices to the paper.

J. P. Vidosic, USA

2114. Kochi, K. C., Characteristics of a self-lubricated stepped thrust pad of infinite width with compressible lubricant, *ASME Trans.* **81** D (*J. Basic Engng.*), 2, 135–146, June 1959.

Harrison's equation for pressure in a gas-lubricated, infinite width bearing, is solved for a stepped thrust pad. Analytic expressions for pressure and load are developed. Charts and graphs are presented for determination of optimum design parameters.

From author's summary by W. J. Anderson, USA

2115. Tanner, R. I., Hydrodynamic lubrication of ball and socket joints, *Appl. Sci. Res. (A)* **8**, 1, 45–51, 1958.

The lubrication equations are solved for an "ideal" ball and socket joint in which the socket totally encloses a steadily rotating, steadily loaded ball. The solution includes the case of no cavitation and the case of a half-cavitated ball. The resulting friction coefficients and load capacity parameters are presented graphically and compared with those for an "ideal" (infinitely wide) plain bearing. The design of actual ball and socket joints (having only partial spheres) is discussed, and it is suggested that the end effects can be estimated by using plain bearing experience in conjunction with the theoretical results for "ideal" joints and plain bearings. M. Hanin, Israel

2116. Tipei, N., Stability of motion in bearings under dynamic load (in Russian), *Zb. Prikl. Mekb. Akad. RNR* **1**, 2, 113–120, 1956; *Ref. Zb. Mekb.* no. 11, 1958, Rev. 12092.

An investigation is made of the stability of motion of a shaft in a round bearing with a movable bushing, the motion of the shaft and the direction of its axis being disregarded. The equations of motion are derived in a movable system of coordinates, the starting point of which is selected at any place in the section of the shaft under examination. Four variables are concerned: two velocity projections of the beginning of the movable system, the velocity of rotation of the dynamic load and the relation of the distance between the centers of the bearing and the bush to the radial clearance between them. The equation coefficients for the variations are averaged and the solution follows with the aid of Hurwicz conditions. Some special cases are investigated; for instance, that of a bearing with a fixed bushing.

E. N. Miroslavlev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Books Received for Review

BINDER, R., Statika, Bratislava, Slovak Publishing House of Technical Literature, 1959, 486 pp. Kcs 33.50.

GIRKMANN, K., Flachentragwerke Einfuhrung in die Elastostatik der Scheiben, Platten, Schalen und Faltwerke, 5th ed., Wien, Springer-Verlag, 1959, xxi + 632 pp. $17.15.

GOURSAT, E., A course in mathematical analysis, Vol. 2, Part 1, Functions of a complex variable, Part 2, Differential equations (Translated from the French by E. R. Hedrick and O. Dunkel), New York, Dover Publications, Inc., 1959, x + 259 pp. $1.65; viii + 300 pp. $1.65 (Paperbound)

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